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Rev. 07/10/02

REPORT

Sources of PCB to the Kalamazoo River – PCB Composition Information

Allied Paper, Inc./Portage Creek/
Kalamazoo River Superfund Site
Kalamazoo, Michigan

March 2003

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BLASLAND, BOUCK & LEE, INC.
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engineers & scientists

Transmitted Via Federal Express

March 20, 2003

Ms. Shari L. Kolak
USEPA Region 5 (SR-6J)
77 West Jackson Boulevard
Chicago, IL 60604-3507

Re: Sources of PCB to the Kalamazoo River
Project No.: 645.02.100 #2

Dear Shari:

This letter transmits additional information regarding sources of PCB to the Kalamazoo River, specifically focusing on the composition of PCB in Kalamazoo River sediment and fish. The Kalamazoo River Study Group (KRSG) has been studying this issue for over ten years and the data are quite compelling that PCB from non-KRSG sources contributes significantly to the levels of PCB found in Kalamazoo fish today. We understand that your consultants did not have the benefit of the extensive information that exists when they reviewed our summary document; we believe that the readily-available information addresses a number of the questions and issues raised in the February 3, 2003 document "Review of Sources of PCBs to the Kalamazoo River" prepared by Syracuse Research Corporation (SRC). In addition to the enclosed information, BBL has an extensive file of information on the topic and we would be pleased to meet with you and your consultants in Syracuse to discuss this important issue.

A brief description of the contents and relevance of each section of the attached document follows:

Section 1. Select Pages From the RI/FS Work Plan. The RI/FS Work Plan anticipated the need for high-quality chromatographic information and congener data for samples analyzed for PCB as part of the Remedial Investigation objectives to be addressed by the data included evaluation of environmental weathering and PCB source identification. This section provides an overview of the methods used to estimate PCB congener concentrations from our routine (SW846 Method 8081) analyses employed by the RI/FS. BBL has a library of diskettes provided by the laboratory with all of the chromatographic data (peak heights, areas, retention times, etc.) for the RI samples. The process of converting that information to estimated PCB congener concentrations was undertaken for the 1993 fish data for forensic analysis. The results of that work are summarized in Sections 2 and 4.

Section 2. Appendix K. PCB Sources and Source Controls on the Kalamazoo River from the draft Remedial Investigation Report – Phase I (October 2000). Quantitative information regarding the composition of PCB in sediments and fish is presented. Much of the PCB composition information summarized in this section was developed in expert reports which are provided in following sections. Towards the end of this section we have attached separate PCB congener ratio plots for carp and

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smallmouth bass collected in 1993 and tables presenting the relative contribution of PCB reported as Aroclors to allow the SRC reviewers to address the question they raised about the potential for bias by grouping carp data with bass data.

Section 3. Report Regarding the Environmental Response at the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site – Fourth Addendum to April 7, 1997 Report (April 27, 1998). Ratios of Aroclor 1242 to 1254 in Kalamazoo River sediment and composition of PCB in fish are presented and discussed. This is one of a series of expert reports that was presented in litigation related to PCB sources in the Kalamazoo River.

Section 4. Report Regarding the Environmental Response at the Allied Paper Inc./Portage Creek/Kalamazoo River Superfund Site – Sixth Addendum to April 7, 1997 Report (July 1, 1999). This document presents a quantitative comparison of PCB composition in fish from Bryant Mill Pond, Morrow Lake and the Kalamazoo River portion of the Superfund site. Information regarding the distribution of PCB mass in sediment is also provided. (The mass estimates were subsequently updated in the October 2000 RI report and changes were relatively small.)

Section 5. Report Regarding the Environmental Response at the Allied Paper Inc./Portage Creek/Kalamazoo River Superfund Site – Seventh Addendum to April 7, 1997 Report (December 28, 2000). This document illustrates relatively small-scale variability in PCB composition in the sediments in the Kalamazoo River in Kalamazoo.

Section 6. Report Regarding the Environmental Response at the Allied Paper Inc./Portage Creek/Kalamazoo River Superfund Site – Eighth Addendum to April 7, 1997 Report (October 9, 2001). This document presents a tabular summary (see Exhibit 7) of the relative amounts PCB quantified as various Aroclors in the Operable Units, the Kalamazoo River by reach, and the exposed sediments in the former impoundments. This report also provides an estimate of the amount of PCB that was transported to the Site from Morrow Lake as well as updated estimates of the amount of PCB in Morrow Lake sediments.

This is an important issue to the long-term management of the Kalamazoo River Site and the KRSG. We are convinced that non-KRSG sources are significant contributors to PCB levels in Kalamazoo River fish today. We expect the data will lead USEPA to the same conclusion. Towards that end, KRSG requests a meeting with USEPA and SRC technical staff to provide a roadmap to the available information and answer any questions about the available data and our analyses. Thank you for your assistance. I look forward to hearing from you.

Sincerely,

BLASLAND, BOUCK & LEE, INC.

Mark Brownpp

Mark P. Brown, Ph.D.
Senior Vice President

MPB/msd

cc: Bonnie A. Barnett, Esq., Drinker Biddle & Reath LLP
J. Michael Davis, Esq., Georgia-Pacific Corporation
Paul A. Montney, P.E., Georgia Pacific Corporation
Joyce S. Schlesinger, P.E., ENVIRON

Section 1

Allied Paper, Inc./Portage Creek/ Kalamazoo River Superfund Site Remedial Investigation/ Feasibility Study Work Plan

Kalamazoo River Study Group

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

July 1993

BLASLAND & BOUCK ENGINEERS, P.C.
BLASLAND, BOUCK & LEE
ENGINEERS & GEOSCIENTISTS

6723 Towpath Road
Syracuse, New York 13214
(315) 446-9120

ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER
SUPERFUND SITE
RI/FS WORK PLAN

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FIGURES (cont'd)

APPENDICES

FIELD SAMPLING PLAN (separately bound)

ASSOCIATED DOCUMENTS AND PLANS (provided separately)

1. Description of Current Situation
2. Health and Safety Plan
3. Quality Assurance Project Plan
4. QA/QC Review of Historical Studies and Data Plan
5. Data Management Plan
6. Plan for Satisfaction of Permitting Requirements
7. Allied Paper, Inc. Operable Unit Work Plan and Field Sampling Plan
8. King Highway Landfill Operable Unit Work Plan and Field Sampling Plan
9. Willow Boulevard/A-Site Operable Unit Work Plan and Field Sampling Plan
10. 12th Street Landfill Operable Unit Work Plan and Field Sampling Plan

5.8 Site Investigation Analysis

5.8.1 Data Analysis

An analysis and summary of all RI data will be prepared and presented to the MDNR in a draft RI Report. Any comments made by MDNR will be addressed in the final document. The results and data from the RI will be organized and presented in a logical manner to describe the relationships between the components of the Site investigations for each affected medium.

In addition to standard reporting of PCB results on an Aroclor basis, the digital files of high resolution PCB chromatographic data from Aquatec will be analyzed to assess congener distributions for all sample media. The congener distribution analysis will be based on the mass analysis of Aroclors on the same gas chromatography column by Aquatec and Schulz et al. (1989) (see Appendix C).

The data from the RI will be analyzed, and a summary of the type and extent of constituents at the NPL Site will be prepared. This information will include a description of the quantities and concentration of specific constituents at the Site and associated ambient levels. There will also be a description of the number, locations, and types of nearby populations, in addition to activities and exposure pathways that may result in an increased risk to public health, welfare, or the environment.

5.8.2 Application to Preliminary Technologies

The data collected during the RI should be of sufficient quality and quantity to support the FS of potential remedial technologies (Table 5-10). The results of the RI will be analyzed in relation to the preliminary technologies developed in Section 5.7.2. Data supporting or rejecting the

Assessment of PCB Congener Distribution Using the Modified USEPA SW-846 Method 8081

PCB congeners present in samples analyzed with the Modified USEPA SW-846 Method 8081 used by Aquatec Inc. (Aquatec) can be identified based on the analysis of commercial Aroclors by Schulz et al. (1989). Schulz et al. (1989) used multidimensional gas chromatograph (GC) - electron capture detector (ECD) analysis to completely characterize the congeners present in commercial Aroclors 1016, 1242, 1254, 1260. From the multidimensional GC-ECD analysis, Schulz et al. (1989) identified peaks which represent single or groups of two to three co-eluting congeners on ECD chromatograms of Aroclors 1016, 1242, 1254, and 1260 from a single SE-54 column (50 meter). Of the 87 identified peaks from the commercial Aroclor chromatograms, 56 peaks represented individual congeners and the remaining 31 peaks comprised two or three co-eluting congeners. Figures 1 and 2 illustrate the peaks identified by Schulz et al.(1989) using the 50-meter SE-54 column for Aroclors 1242 and 1260.

The chromatograms generated from Aquatec's Modified USEPA SW-846 Method 8081 are from a RTX-5 column (30 meter). The RTX-5 column is analogous to the SE-54 column in packing material: 5% diphenyl-95% dimethyl polysiloxane. Therefore the RTX-5 column is expected to generate a chromatogram pattern nearly identical to the SE-54 chromatogram for comparable chromatograph conditions. Aroclor 1242 and combined Aroclor 1016 and 1260

standard chromatograms generated from Aquatec's RTX-5 column are shown in Figures 3 and 4, respectively. Comparing the SE-54 and the RTX-5 chromatograms, correspondence of the chromatographic patterns of peaks generated from the SE-54 column and Aquatec's RTX-5 can be readily seen (See numbered peaks for SE-54 and RTX-5 chromatograms). Because of the similarity of the RTX-5 and the SE-54 chromatograms, congener identifications can be made by comparing the two chromatograms, identifying like peaks, and then relating the like peaks to specific congeners with the peak/congener identifications derived from multidimensional GC-ECD analysis. Congener assignments for the RTX-5 column are provided in Table 1.

Sample congener concentrations would be estimated using the mass analysis of Aroclors reported by Schulz et al. (1989) and the sample and standard ECD responses provided by Aquatec for the RTX-5 column.

Aquatec's Chromatogram Digital Format

The digital format of the chromatographic data Aquatec will provide to Blasland & Bouck consists of seven fields: peak group, retention time (min.), retention time expected (min.), peak height (uV), peak area (uVs), peak width (sec.), and parts per billion concentration of peak (Table 1). The most important field which will be used in congener identification is the retention ti[illegible]

field. The digital format will allow for easy scanning and congener identification of sample chromatograms via a microcomputer.

Reference

Schulz, D.E., G. Petrick, and Jan C. Duinker, "Complete Characterization of Polychlorinated Biphenyl Congeners in Commercial Aroclor and Clophen Mixtures by Multidimensional Gas Chromatography-Electron Capture Detection," Environmental Science & Technology, Vol. 23, (1989), pp 852-859.

Table C-1

Allied Paper, Inc./Portage Creek/Kalamazoo River
Superfund Site

PCB Congener Identification of Aroclors 1242 and 1260
from Aquatec's RTX-5 Column

Peak Number	IUPAC Number	
	Aroclor 1242	Aroclor 1016/1260[2]
4	8 5[1]	-- --
5	19	--
6	18 17 15	-- -- --
7	24 27	-- --
8	16 32	-- --
11	26	--
12	25	--
13	31 28	-- --
14	20[1] 30 53	-- -- --
15	51[1] 22	-- --
16	45	--
17	46	--
19	52	--
20	49	--

Table C-1

Allied Paper, Inc./Portage Creek/Kalamazoo River
Superfund Site

PCB Congener Identification of Aroclors 1242 and 1260
from Aquatec's RTX-5 Column

Peak Number	IUPAC Number	
	Aroclor 1242	Aroclor 1016/1260[2]
21	47 48 75[1]	-- -- --
23	44	--
24	37 59 42	-- -- --
25	41 64	-- --
27	40	--
30	74	--
31	70	--
32	66 95	-- --
34	91	--
35	60 56	-- --
38	90 101	-- --
39	99	--
42	97	--
43	87 115[1]	-- --
44	85	--
45	--	136

Table C-1

Allied Paper, Inc./Portage Creek/Kalamazoo River
Superfund Site

PCB Congener Identification of Aroclors 1242 and 1260
from Aquatec's RTX-5 Column

Peak Number	IUPAC Number	
	Aroclor 1242	Aroclor 1016/1260[2]
46	77 110	77[1] 110
47	82 151[1]	82[1] 151
48	--	135
50	123[1] 149 118	123[1] 149 118[1]
53	--	146
54	132 153 105	132 153 105[1]
55	--	141 179
57	--	176 137[1]
58	160[1] 138 158[1]	160 138 158
59	--	129 126[1] 178
61	--	187
62	--	183
63	--	128
65	--	185

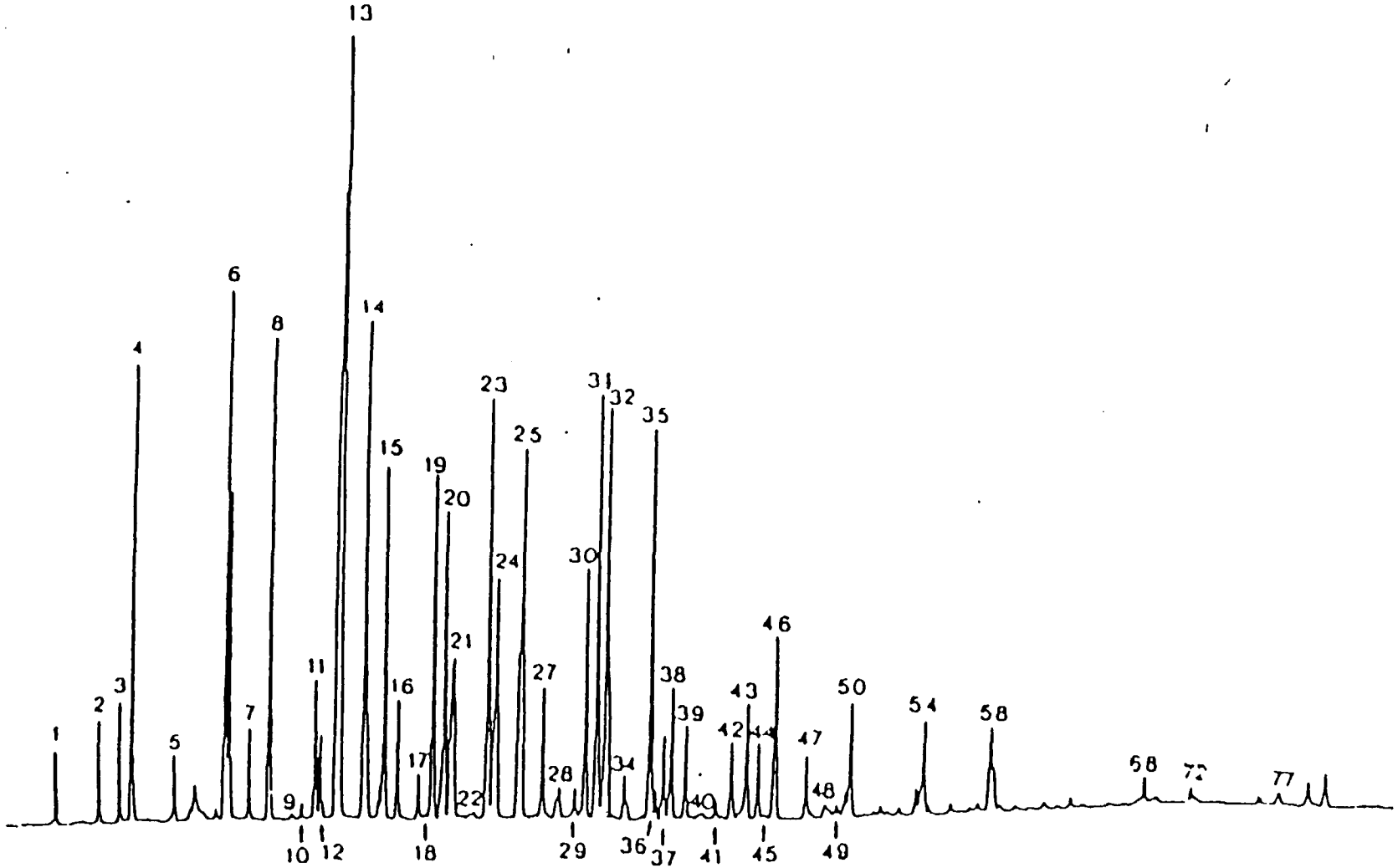
Table C-1

Allied Paper, Inc./Portage Creek/Kalamazoo River
Superfund Site

PCB Congener Identification of Aroclors 1242 and 1260
from Aquatec's RTX-5 Column

Peak Number	IUPAC Number	
	Aroclor 1242	Aroclor 1016/1260[2]
66	--	174
67	--	177
68	--	202 171 156
69	--	173 157 201
70	--	172
72	--	180
75	--	200
77	--	170 190
79	--	199
80	--	203 196
82	--	208 195
84	--	194
86	--	205

Note:
[1] Represents less then 5 percent of the total mass of the co-eluting congeners.
[2] Represents only Aroclor 1260 portion of chromatogram.



REFERENCE: SCHULZ ET AL., (1989)

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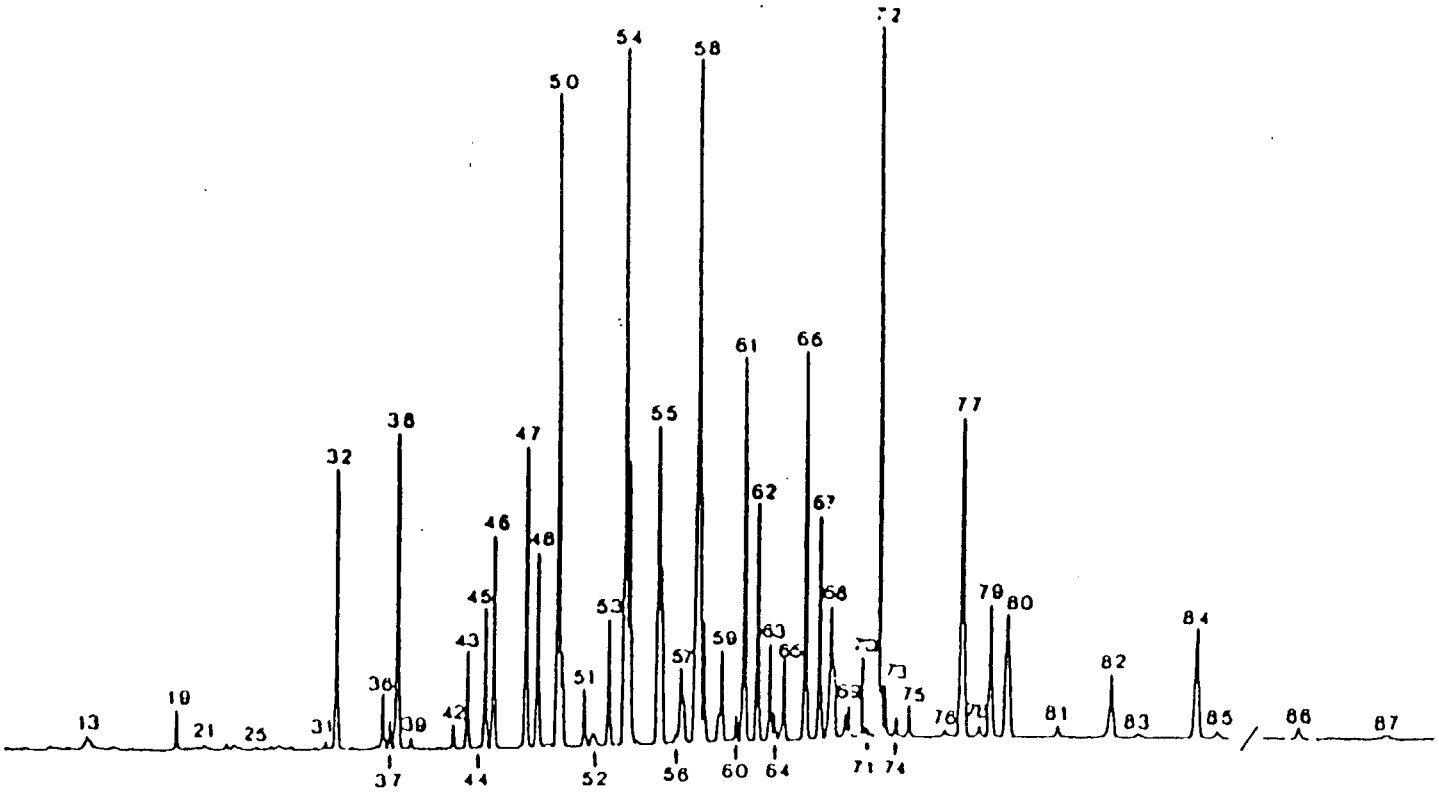
ENGINEERS & SCIENTISTS

KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER INC. / PORTAGE CREEK
KALAMAZOO RIVER SUPERFUND SITE

AROCLOR 1242
ANALYZED BY
SE-54 COLUMN

FIGURE
1

646.24.37



REFERENCE: SCHULZ ET AL., (1989)

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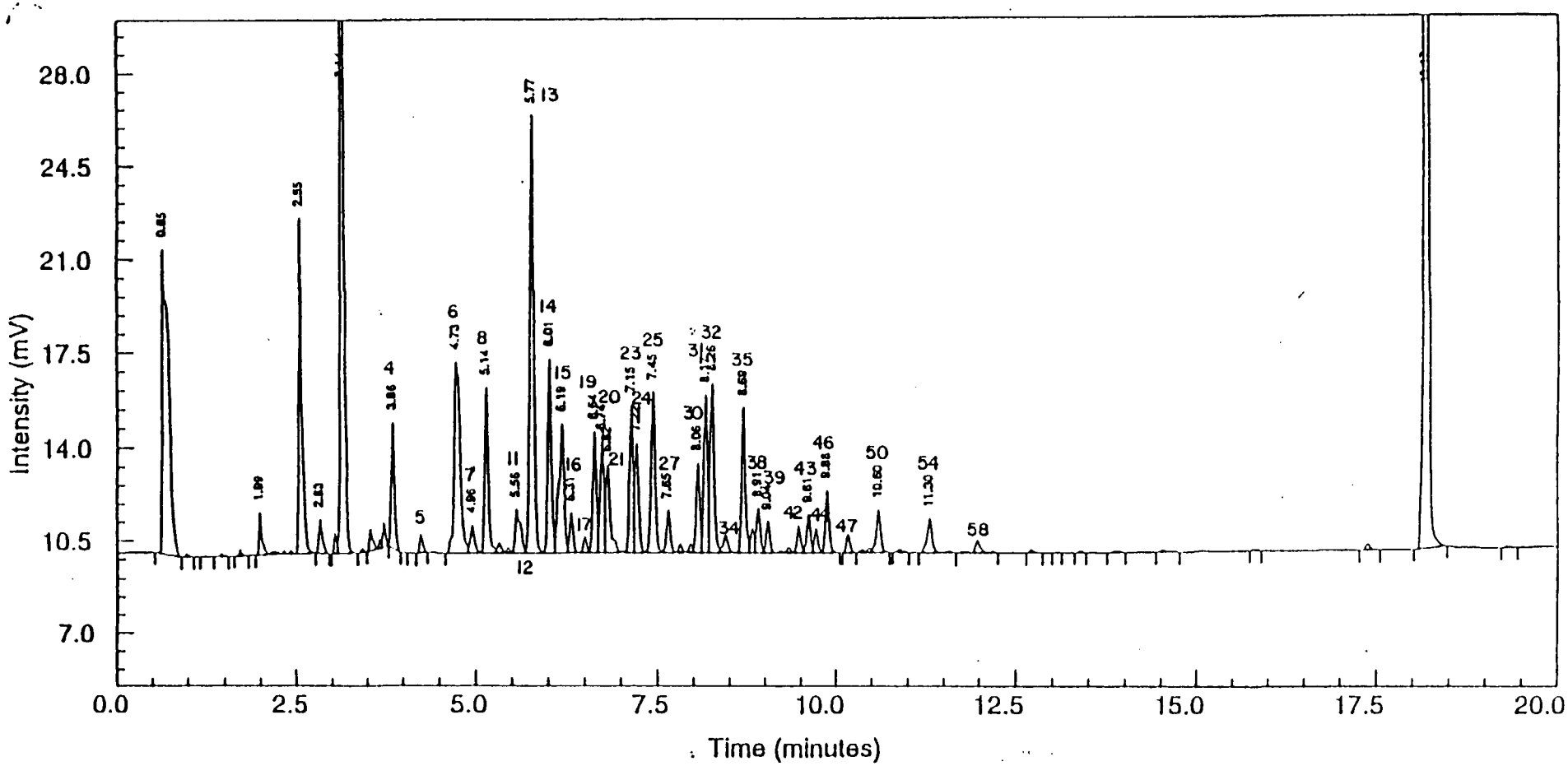
ALLIED PAPER INC./PORTAGE CREEK
KALAMAZOO RIVER SUPERFUND SITE

AROCLOR 1260
ANALYZED BY
SE-54 COLUMN

FIGURE
2

JUNE 1993
648.24.37



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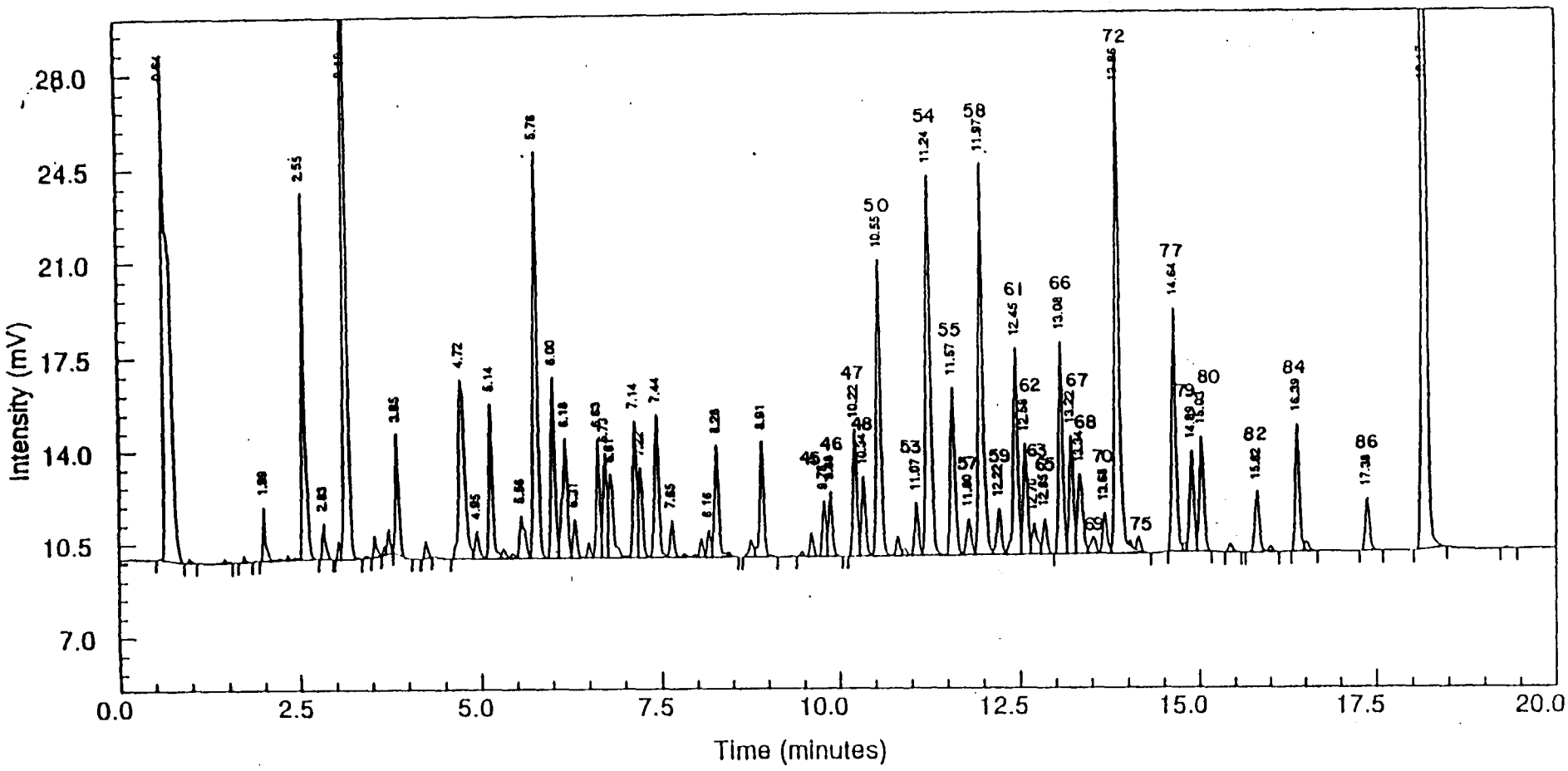
KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER INC. / PORTAGE CREEK
KALAMAZOO RIVER SUPERFUND SITE

AROCLOR 1242
ANALYZED BY
RTX-5 COLUMN

FIGURE
3



REFERENCE: AQUATEC INC. 1993

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ENGINEERS & SCIENTISTS

KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER INC./ PORTAGE CREEK
KALAMAZOO RIVER SUPERFUND SITE

AROCLOR 1016 AND 1260
ANALYZED BY
RTX-5 COLUMN

FIGURE
4

JUNE 1995
648.24.37

Section 2

REPORT

DRAFT FOR STATE AND FEDERAL REVIEW

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site RI/FS

Remedial Investigation Report - Phase I

Volume 2 of 2

Allied Paper, Inc./Portage Creek/
Kalamazoo River Superfund Site
Kalamazoo and Allegan Counties,
Michigan

October 2000

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Appendix K

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PCB Sources and Source Controls on the Kalamazoo River

Appendix K: PCB Sources and Source Controls on the Kalamazoo River

The presence of polychlorinated biphenyls (PCB) in the Kalamazoo River, particularly within the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Site), has been the subject of a number of studies since PCB were first identified in its water, sediments, and fish in 1971[1]. PCB have entered the Kalamazoo River by routes including direct discharge (e.g., wastewater effluent), indirect discharge through publicly owned treatment works (POTWs), non-point source runoff from upland areas, and erosion of exposed PCB-containing sediments from riverbanks. Point sources that contributed PCB to the river include paper-manufacturing facilities that recycled waste paper between the late 1950s and early 1970s, and a variety of other industries that used PCB products. PCB were widely used to insulate and transfer heat in electrical systems, and were also used in the manufacture of carbonless copy paper from 1957 through 1971. Although carbonless copy paper was not manufactured by paper companies in the Kalamazoo River basin, it was included in some post-consumer wastepaper that was recycled by local paper companies.

The Kalamazoo River Study Group (KRSG) is made up of current and former owners of some of the paper mills and recycling facilities that recycled post-consumer waste paper in the Kalamazoo River watershed. Because some of this waste paper included carbonless copy paper manufactured with PCB, the recycling process produced a waste stream containing PCB. During this era, recyclers were unaware that they were handling and discharging PCB. At that time, wastewater discharge regulations were focused on improving water clarity and levels of dissolved oxygen (DO) in the Kalamazoo River, and the potential hazards of PCB were not recognized or well understood.

Identification of non-KRSG sources of PCB to the river and an assessment of their contribution, both past and present, are important because any remedial effort focused on PCB will only succeed if all sources of PCB are controlled.

This appendix summarizes information pertinent to the assessment of both past and present sources of PCB to the Site. This information was compiled based on:

- A series of investigations into known and potential dischargers of PCB to the Site;

[1] These studies are summarized in the *Description of the Current Situation* (DCS) Report (BBEPC, 1992).

- Results of the Remedial Investigation (RI), including sediment and fish PCB data, providing empirical evidence of historical and ongoing discharges of PCB that cannot be attributed to paper recycling; and

- Results from investigations and remedial activities at the KRSG mills and Operable Units (OUs).

This information shows that: 1) KRSG sources have been controlled or will soon be controlled due to a series of response actions already accomplished or under way, 2) the largest external ongoing source of PCB to the Kalamazoo River is the miles of eroding and erodible riverbank created when the Michigan Department of Natural Resources (MDNR) drew down the water levels in its three former impoundments at Plainwell, Otsego, and Trowbridge, and 3) uninvestigated point and non-point sources upstream of the Site and elsewhere in the watershed may still be significant with respect to sustaining the levels of PCB observed in fish.

Known and Potential Historical Dischargers of PCB to the Site

In the United States, PCB were produced for commercial purposes exclusively by Monsanto under the trade name Aroclor. The average chlorine content of a particular Aroclor product in most cases was evident in the specific product name. For example, Aroclor 1242 is 42% chlorine by weight. Although most PCB produced in the United States were used in electrical component manufacturing (i.e., capacitors and transformers), they also were used in other applications, including hydraulic fluids, cutting oils, heat transfer fluids, wax casting, and carbonless copy paper (Durfee et al., 1976).

The presence of PCB attributable to paper and non-paper industries is evident in the Kalamazoo River RI data. The PCB composition of paper-making residuals (residuals) studied at the OUs is dominated by PCB apparently originating from and still resembling Aroclor 1242. Higher-chlorinated PCB Aroclors (e.g., Aroclors 1254 and 1260), which were more often used in electrical equipment and other applications, typically are not found or are evident in very low concentrations in residuals. However, as described in the RI report, PCB from higher-chlorinated Aroclors have consistently been detected in fish, sediment, and water collected from the Kalamazoo River. In fact, some samples contained elevated PCB resembling Aroclor 1254 with little or no "lower" Aroclors identified.

When manufactured, Aroclors were composed of various combinations of chlorobiphenyls. As shown in the table below, Aroclor 1242 does not contain concentrations of hexa-, hepta-, octa-, or nona-chlorobiphenyls (the higher-chlorinated chlorobiphenyls), while Aroclors 1254 and 1260 do contain these chlorobiphenyls.

Chlorobiphenyl	% in Aroclors			
	Aroclor 1242	**Aroclor 1248**	**Aroclor 1254**	**Aroclor 1260**
Mono-	1	--	--	--
Di-	13	1	--	--
Tri-	45	22	1	--
Tetra-	31	49	15	--
Penta-	10	27	53	12
Hexa-	--	2	26	42
Hepta-	--	--	4	38
Octa-	--	--	--	7
Nona-	--	--	--	1

Reference: Erickson, 1997.

Dyes and Aroclor 1242 were contained within the hardened microcapsules on the back of carbonless copy paper. This use of Aroclor 1242 resulted in PCB contamination of waste paper sources and secondary fiber nationally. Approximately 44 million pounds of Aroclor 1242, roughly 6% of Monsanto's domestic sales of all Aroclors between 1957 and 1971, were sold for use in carbonless copy paper manufacturing (Carr et al., 1977). None of the KRSG paper companies were involved in the manufacture of this PCB-containing paper. However, when waste paper containing the carbonless copy paper was recycled, PCB were inadvertently released to the environment.

By 1971, concerns had grown regarding the persistence and bioaccumulation of PCB in the environment, and Monsanto decided to restrict PCB sales to applications involving only closed electrical systems. In 1971, PCB were replaced by alkyl-biphenyls in the production of carbonless copy paper, and the amount of PCB discharged by paper recycling facilities diminished rapidly (Carr et al., 1977). The manufacture of all PCB in the United States ceased in 1977 (Agency for Toxic Substances and Disease Registry [ATSDR], 1997).

Aroclor 1254 received limited use within the paper industry in "flexographic" inks that were used on plastic packaging. Carr et al. (1977) estimated that a total of 50,000 pounds of Aroclor 1254 were used nationwide in these inks. Given the nature of this packaging (plastic or paper containing plastic adhesives that contained negligible amounts of fiber), it would not have been an attractive stock for recycling. Consequently, Carr et al. (1977) concluded that these inks were unlikely to have significantly contributed PCB to waste streams within the paper

industry. Therefore, it is reasonable to assume that deinking operations involving carbonless copy paper generated a waste stream containing Aroclor 1242, but no appreciable amount of Aroclor 1254.

Several KRSG mill properties and the four OUs within the Site have been eliminated as sources of PCB to the Kalamazoo River. Active use of the OUs has ceased, and each mill property and OU has separate remedial programs complete or under way. Remedial activities at these locations, briefly described later in this appendix, include the consolidation of residuals into landfills, capping and closing of landfills, removal of material from the sediment beds immediately adjacent to some OUs, and the complete removal of sediment from the former Bryant Mill Pond. The combined OU remediations have isolated an estimated 55,000 kilograms (kg) of PCB, approximately one-half of the total PCB mass within the entire Site (i.e., OUs, river, and former impoundments).

Non-KRSG Sources

Paper mills along the Kalamazoo River that are not represented by KRSG members also used waste paper as feedstock, and therefore handled and discharged PCB. In addition to paper mills, numerous facilities along the Kalamazoo River are known purchasers and/or dischargers of PCB to the Kalamazoo River.

In addition to industrial facilities, another potential external non-point source of PCB to the Kalamazoo River is general runoff from industrialized urban areas. This runoff may contain additional "reservoirs" of PCB that could be mobilized and transported to the river. For example, PCB-containing sediments and other solids probably persist in sewer systems or storm drainageways, albeit at much lower levels than historical maximums. Similarly, exposed soils that may have been affected by PCB (e.g., soils at scrapyards such as the KAMAR facility in Kalamazoo, where PCB have been detected in shredded scrap metal "fluff" from automobiles) may be transported to the river via non-point surface water runoff.

Exposed Former Sediments

Based on RI data and calculations presented in Appendix G, the exposed former sediments within the three state-owned former impoundments appear to be the greatest remaining external source of PCB to the Kalamazoo River. An estimated 24,500 kg of PCB are contained in the approximately 2,800,000 cubic yards (cy) of former sediments that were exposed when the MDNR drew down the Plainwell, Otsego, and Trowbridge impoundments in the 1970s. As the impoundments were drawn down and water levels fell, the Kalamazoo River cut a new channel into the impoundment sediments, releasing the underlying PCB-containing material and dispersing it downstream. At the same time, the approximately 1,100-acre combined surface area of the three impoundments was drained, thereby

exposing the former sediments on either side of the newly cut river channel. Since drawdown in the 1970s and subsequent removal of the remaining dam structures down to their sills in 1987, the river has been flowing through, and coming in contact with, this mass of PCB-containing former sediments. Consequently, the banks of the river channel have been susceptible to sloughing and erosion, which appear to be the most significant transport pathway for ongoing external loading of PCB to the river downstream of Plainwell. This is an important point, because this continual influx of bioavailable PCB may be substantially affecting PCB concentrations in fish – the only significant exposure pathway for both humans and ecological receptors. Surface runoff may represent another potential transport pathway for these source materials, but such a pathway is expected to be much less significant due to the relatively level topography of the exposed sediment areas and the fact that the riverbanks are heavily vegetated and appear stable (except along their exposed banks at the river's edge).

Inactive Hazardous Waste Sites

Within Allegan and Kalamazoo counties, there are four National Priorities-Listed (NPL) sites: three in Kalamazoo County and one in Allegan County. These sites are described below.

The Rockwell International Corporation Superfund Site (Rockwell Site) (USEPA ID # MID006028062) is located in the City of Allegan, along the Kalamazoo River, downstream of the Allegan City Dam. The majority of the Rockwell Site is still in the Remedial Investigation/Feasibility Study (RI/FS) stage; a No Action Record of Decision (ROD) for the on-site landfill was signed in 1995. The Auto Ion Chemicals, Inc. Superfund Site (Auto Ion) (USEPA ID # MID980794382) is located in the City of Kalamazoo, on the Kalamazoo River upstream of the Portage Creek confluence. In 1985, remedial action was performed, and the abandoned building was torn down in 1986. The Michigan Disposal/Cork Street Landfill USEPA Superfund Site is located in the City of Kalamazoo. Davis Creek, which empties into the Kalamazoo River, borders a portion of the eastern site boundary. A cap is currently under construction. The K&L Avenue Landfill (USEPA ID # MID980506463) is located in Oshtemo Township and is not located near the Kalamazoo River.

Three of these NPL sites have had PCB contamination, and at least two (Rockwell International Superfund Site and Auto Ion Superfund Site) have very clear evidence of PCB discharges to the river. In the discharge from Auto Ion, up to 12 milligrams per kilogram (mg/kg) of Aroclor 1254-like PCB was detected in a mound of sediment in the river 5 feet downstream of the historical discharge from the site (total PCB in this sample was 39 mg/kg). This Superfund site is also in the immediate vicinity of KPT-20 sediment cores, where elevated PCB concentrations, quantitated as Aroclor 1254, were detected down to 5 feet deep in the sediment bed, a depth of contamination quite uncharacteristic elsewhere in the Kalamazoo River. Water samples collected from the river behind a boom that contains oil seeping

from the Rockwell Site also contained an Aroclor 1254-like PCB, which marks the releases from that site (Brown, 1997).

According to the MDEQ, there are 46 sites in Allegan County and 96 sites in Kalamazoo County in the Part 201 *Contaminated Sites in Michigan Database*, with 6 sites listing PCB as a pollutant. Five of the 96 sites in Kalamazoo County list PCB as a pollutant. Other than the Site, the listed facilities are the Speareflex Site in the City of Kalamazoo, the Panelyte Site in the City of Kalamazoo (adjacent to the Allied Paper, Inc. Operable Unit [Allied OU]), the D Ave Cooper Township Site in Cooper Township, and the Former Consumers Energy Site in the City of Kalamazoo. Of the 46 Allegan County sites, only the Rockwell Site has PCB listed as a pollutant (MDEQ, 1999). All of the sites that list PCB as a pollutant are located in the vicinity of or along the shores of the Kalamazoo River.

According to the MDEQ, there are 73 sites in Calhoun County in the Part 201 *Contaminated Sites in Michigan Database*, with 2 sites listing PCB as a pollutant. The Brooks Foundry Building Area and the Brooks Foundry Lagoon Area are both located near the North Branch of the Kalamazoo River in Albion (MDEQ, 1999).

The approximate locations of these Superfund sites and the Part 201 sites are presented on Figure 1.

Empirical Evidence of Non-Paper Sources in PCB Composition

In the early stages of the RI, it became apparent there were significant sources of PCB to the Kalamazoo River unrelated to the activities of the KRSG members. The clearest illustration of this was the PCB-related fish consumption advisories for Morrow Lake and the measured levels and types of PCB found in Morrow Lake sediment. Morrow Lake is upstream of the Site and all KRSG facilities. More subtle information was discovered upon review of the chemical fingerprints of the composition of PCB found in fish collected and analyzed by the State of Michigan.

Data from samples collected upstream of the KRSG facilities and the Site show that PCB are present in the river prior to any influence from a KRSG facility. For example, historical sediment and surface water PCB data for Morrow Lake presented in the DCS (BBEPC, 1992) show that a maximum PCB concentration of 2.4 mg/kg was detected in surficial sediment samples from Morrow Lake. Downstream of Morrow Dam, four sediment transects (KPT-1 through KPT-4) upstream of any KRSG facilities or OUs were collected in 1993 as part of the sediment investigation. PCB, quantified as Aroclor 1254, were detected in 5 out of 36 core samples from these transects. PCB were also detected in a number of surface water samples collected at River Street in Comstock in 1985 and 1986, and in a sample collected during the surface water investigation (see Sections 2 and 4 of the RI Report for details). In addition, PCB have been detected in fish from Morrow Lake and near Ceresco, also upstream of the Site. The

MDCH's current fish advisory recommends no consumption of carp from the Kalamazoo River from Battle Creek to Morrow Dam due to the presence of PCB (MDCH, 2000).

Additional data were collected in the fall of 1999 when MDEQ/Camp Dresser & McKee, Inc. (CDM) collected surface water samples at 20 sampling locations on the Kalamazoo River and four locations on Portage Creek. At each sampling location, surface water samples were collected from the left and right banks and at mid-channel and submitted for total PCB and total organic carbon (TOC) analysis. Of the 20 sampling locations on the Kalamazoo River, four sampling locations were located upstream of KRSG facilities and OUs (Ceresco Dam, Morrow Dam, Comstock, and Sprinkle Road). Analytical results for surface water samples collected at all four locations indicated detectable concentrations of PCB. On October 21, 1999, a sample collected from the right bank of the Comstock sampling location had a total PCB concentration of 11 nanograms per liter (ng/L). This concentration was greater than 43% of all samples collected downstream of Sprinkle Road.

On Portage Creek, two of the four sampling locations were upstream of KRSG facilities and OUs. One sample, collected on October 21, 1999, had a total PCB concentration of 11 ng/L. This concentration was greater than 79% of all samples collected downstream of KRSG facilities and OUs.

On January 11, 2000, MDEQ/CDM collected more surface water samples along Portage Creek (four locations) and the Kalamazoo River (seven locations) for homolog-specific PCB analysis. Two locations on Portage Creek and two locations on the Kalamazoo River were upstream of the KRSG facilities and OUs. At each location, samples were collected from the left bank, mid-channel, and right bank.

The two upstream locations on the Kalamazoo River were Comstock and Sprinkle Road. All three samples collected near Comstock had nondetectable total PCB concentrations. The sample collected near the right bank near Sprinkle Road had a total PCB concentration of 1.6 ng/L (35% were identified as trichlorobiphenyls, and 65% were identified as tetrachlorobiphenyls).

The two upstream locations on Portage Creek were Garden Lane and Kilgore Road. The sample collected near the left bank near Garden Lane, which forms the upstream boundary of Bicentennial Park, had a total PCB concentration of 2.1 ng/L (78% were identified as trichlorobiphenyls, and 22% were identified as tetrachlorobiphenyls). All three samples collected near Kilgore Road had nondetectable total PCB concentrations. The sample collected near the right bank near Cork Street, which forms the upstream boundary of the Allied OU, had a total PCB concentration of 5.8 ng/L (22% were identified as dichlorobiphenyls, 47% were identified as trichlorobiphenyls, and 32% were identified as tetrachlorobiphenyls).

Analytical traces known as chromatograms provide information, akin to a "fingerprint," regarding the composition of PCB in fish found at the Site. Chromatograms can identify substantial differences between the composition of PCB in fish that could potentially be attributed to paper manufacturing and the PCB composition actually found in many Kalamazoo River fish. For example, the PCB found in carp samples collected in Morrow Lake in 1986 are characterized by much higher proportions of heavier PCB compounds (i.e., higher molecular weight such as Aroclor 1254) than the composition of the PCB found in Portage Creek carp collected during the same sampling event. The lighter PCB compounds found in Portage Creek fish reflect exposure to releases associated with waste paper recycling at the local paper mills during the 1960s, while the heavier PCB compounds detected in Kalamazoo River fish are associated with releases not related to waste paper recycling.

The composition of PCB found in fish within the Kalamazoo River downstream of Portage Creek clearly shows the contribution of PCB compounds from sources other than papermaking. Chromatograms for Lake Allegan fish reflect PCB composition very similar to chromatograms for Morrow Lake fish, which have the heavier PCB composition. There is also some correspondence between the chromatograms for the Lake Allegan fish and the Portage Creek fish; however, the evidence of non-paper industry sources of PCB to Kalamazoo River fish is unmistakable. This evidence further supports the conclusion that there were historical non-paper PCB discharges to the Kalamazoo River, some of which still may be active and may be influencing the level of PCB in Kalamazoo River fish. Consequently, the potential current contribution of these PCB sources must be addressed to ensure effective remediation of the Site.

Based on an evaluation of sediment and fish PCB data for the Kalamazoo River from the Ceresco Impoundment through New Richmond (downstream of the Site), there is evidence of releases from PCB sources unrelated to the recycling of waste paper. Chromatographic data and the reported best-fit Aroclor-equivalent concentrations were evaluated for evidence of PCB sources that cannot be reasonably explained by releases originating from the recycling of waste paper.

Aroclor-equivalent concentration data (the amount of PCB quantified as various Aroclors in sediment and fish) have been produced by the Site's analytical laboratory on a consistent basis using a statistical method. In this method, chromatograms of individual Aroclors and various combinations of Aroclors are statistically compared (step-wise multiple linear regression) to the chromatogram of a fish or sediment sample. The comparison that produces the least error is then used to quantify the total PCB in the sample as a single Aroclor or combination of multiple Aroclors.

The spatial distribution of sediment chromatographic data and Aroclor data were reviewed for evidence of discontinuities or gradients that might suggest the influence of a particular historical or current point source of PCB. Because fish play a central role in determining the need for responses at aquatic sites with PCB contamination such

as the Kalamazoo River, the spatial distribution of fish chromatographic data and Aroclor data were also evaluated to determine the significance of non-paper PCB sources.

Evidence of spatial gradients in the composition of sediment PCB was assessed through three approaches. The first approach estimated the average chlorine content of the PCB mixtures in sediment samples. These estimates were obtained by summing the product of each of the Aroclor-equivalent concentrations in a sediment sample and the percent weight of chlorine in the particular Aroclor used for quantitation. The second approach evaluated the ratios of Aroclor 1242 to Aroclor 1254. Aroclor 1242 and Aroclor 1254 were used because there is clear evidence of their discharge to the river, and their compositions do not overlap to a great degree. These ratios were calculated for all samples that had more than 60% of the total PCB quantitated as Aroclor 1242 and/or Aroclor 1254. The third approach involved the estimation of PCB homolog distributions in each of the river segments. The distribution of homologs was approximated by applying the known distribution of PCB homologs in Aroclors (Erickson, 1997) to the Aroclor equivalent concentrations of PCB in sediment.

Figure 2 displays the average chlorine content of the PCB mixtures found in sediment samples by location along the Kalamazoo River from Morrow Dam through Lake Allegan. The data are displayed for samples that contained PCB concentrations in excess of 1 mg/kg. Average percent chlorination in sediment samples, as displayed in Figure 2, varies over a range from 42% to 60%. The data show only a very slight downward trend with increasing distance along the Kalamazoo River; the regression line through the data implies a decrease of 3.5% chlorine content from 47.5% content to 44% chlorine content between Morrow Dam and Lake Allegan Dam, as reflected on Figure 2. There do not appear to be any abrupt discontinuities that can be identified within the overall scatter of the plotted data that would suggest the influence of a single point source of PCB.

Similarly, the ratio of PCB quantified as Aroclor 1242 to that quantified as Aroclor 1254 in sediment samples, shown on Figure 3, generally increases with distance along the river; however, no abrupt shifts that might be evident of a substantial influence of a single point source are apparent within the scatter of data. The data in Figure 3 have been separated to discriminate between surface and subsurface sediment samples and concentrations greater than 10 mg/kg PCB as well as concentrations less than 10 mg/kg PCB. As in Figure 2, there are no abrupt discontinuities along the length that would identify a substantial influence of any single point source of PCB.

Table 1 presents summary information regarding the distribution of Aroclor 1242 to Aroclor 1254 ratios in the Kalamazoo River and Portage Creek sediment. Compared to the Kalamazoo River, ratios of Aroclor 1242 to Aroclor 1254 are higher in Portage Creek, reflecting a much greater proportion of Aroclor 1242-like PCB attributable to historical paper-making operations in the vicinity and upstream of Alcott Street along Portage Creek. Evidence of

discharges of other types of PCB (including Aroclor 1254) to Portage Creek by sources other than paper-making operations was found in two samples collected at the same location immediately upstream of Axtell Creek, which contained 69 and 3.4 mg/kg of PCB quantified in total as Aroclor 1254.

The distribution of Aroclor 1242 to Aroclor 1254 ratios for Portage Creek can be considered a conservative model of the ratios of Aroclor 1242 to Aroclor 1254 that would exist in the Kalamazoo River if the only source of PCB to the river had been the recycling of waste paper. It is conservative because, as noted above, there is very clear evidence of historical Aroclor 1254 discharges in Portage Creek in the area of Axtell Creek. Waste paper recycling might actually have a higher Aroclor 1242 to Aroclor 1254 ratio than the distribution provided in Table 1 for Portage Creek. Despite the possibility that the contribution of waste paper recycling could be overestimated by using Portage Creek as a reference, it is apparent that the ratios of Aroclor 1242 to Aroclor 1254 in Portage Creek sediment are much higher than the ratios found in sediments along the Kalamazoo River. The principal reason for the difference in Aroclor 1242 to Aroclor 1254 ratios between Portage Creek and the Kalamazoo River is the greater contribution of higher molecular weight (i.e., Aroclor 1254-like) PCB from sources other than waste paper recycling to the river.

The approximate homolog composition of sediment PCB mixtures along the Kalamazoo River and Portage Creek is illustrated on Figure 4. These homolog distributions represent averages determined by concentration weighting (Schulz et al., 1989). The data for the Kalamazoo River relative to Portage Creek display subtle increases in the relative amounts of pentachlorobiphenyls and hexachlorobiphenyls with increasing distance downstream of Portage Creek. Furthermore, the data show substantially higher relative concentrations of pentachlorobiphenyls and hexachlorobiphenyls upstream of Portage Creek. As discussed below, these increases in pentachlorobiphenyls and hexachlorobiphenyls, which cannot be accounted for by discharges from waste paper recycling, are significant because these are the homologs that comprise the highest PCB levels observed in fish. This means there have been sources of heavier PCB mixtures such as Aroclor 1254 within and upstream of the Site.

For equal levels of exposure to Aroclor-derived PCB, fish accumulate more hexachlorobiphenyls than pentachlorobiphenyls, more pentachlorobiphenyls than tetrachlorobiphenyls, more tetrachlorobiphenyls than trichlorobiphenyls, and more trichlorobiphenyls than dichlorobiphenyls. Dichlorobiphenyls and monochlorobiphenyls are accumulated only to a very slight extent.

Figure 5 presents fish chromatograms for white suckers collected from Bryant Mill Pond, Morrow Lake, and the Trowbridge Impoundment in addition to chromatograms for Aroclor 1242 and 1254 standards (Figure 6). Suckers were used to illustrate the PCB compositions because they represent the most standardized fish sample collected

upstream of and within the Site. The three specimens used to illustrate PCB composition represent the upper end of PCB concentrations measured in white sucker at these locations.

Chromatograms from the fish tissue PCB analyses can be compared by identifying common peaks to indicate the relative abundance of certain PCB compounds. For example, peak "G" in each of the chromatograms on Figures 5 and 6 is the same peak. The labeling also includes the number of chlorine atoms associated with the predominant PCB compounds believed to be associated with each peak.

The similarity between Morrow Lake fish and Aroclor 1254 can be seen by examination and comparison of the prominent amplitude of peaks G through K on Figures 5 and 6. In contrast, peaks G through K have a relatively low amplitude in both Aroclor 1242 (Figure 6) and Bryant Mill Pond fish (Figure 5). The Bryant Mill Pond fish chromatogram represents the distribution of PCB resulting from concentrated exposure to PCB originating from waste paper recycling. By comparison, Figure 5 presents a chromatogram for a fish collected in the Trowbridge Impoundment, downstream of both Morrow Lake and Bryant Mill Pond, which clearly shows in peaks G through K the prominence of Aroclor 1254 as well as the presence of peaks also seen in Bryant Mill Pond fish and Aroclor 1242 (e.g., peaks A through G).

The figures illustrate the predominance of Aroclor 1242-derived PCB in Bryant Mill Pond fish and the predominance of Aroclor 1254-like PCB in Morrow Lake fish. In fish from the Trowbridge Impoundment, there is very clear evidence of higher levels of Aroclor 1254-like PCB than those found in Bryant Mill Pond fish. The levels of Aroclor 1254-like PCB in the Trowbridge Impoundment fish cannot be explained by waste paper recycling sources of PCB alone.

Aroclor 1254-derived PCB congeners are prominent in the composition of PCB found in Kalamazoo River fish. These PCB congeners are prominent because they bioaccumulate in fish to a greater extent than Aroclor 1242-derived PCB congeners. The propensity for PCB to bioaccumulate in fish has been related to the chemical property referred to as the octanol-water partition coefficient (K_{ow}). In general, PCB congeners with greater K_{ow} values will accumulate to higher levels in aquatic biota than will PCB congeners with lesser K_{ow} values. Figure 7 is a figure taken from a research article by Parkerton et al. (1993) that relates the biota sediment accumulation factor (BSAF) for PCB to the logarithm of the octanol-water partition coefficient (log K_{ow}). The BSAF is the ratio of PCB levels in an aquatic organism to the PCB level in surface sediment. To this figure, lines were added showing the approximate log K_{ow} for Aroclor 1242 and Aroclor 1254 (taken from ATSDR, 1998; also see Shiu and Mackay, 1986 for K_{ow} values for PCB congeners) and the corresponding BSAFs. As illustrated on Figure 7, for equal amounts of Aroclor 1242 and

Aroclor 1254 in surface sediment, aquatic organisms would accumulate more than three times the amount of Aroclor 1254-like PCB than Aroclor 1242-like PCB.

To evaluate the approximate quantity of Aroclor 1254-derived PCB congeners in Kalamazoo River fish, the estimated PCB congener concentrations associated with certain chromatogram peaks from Kalamazoo River fish samples taken from different points along the river. The chromatogram peaks for which PCB congener concentrations were estimated are peaks A, G, and K, which were previously discussed. Peak A congeners are prominent components of Aroclor 1242 and fish from Bryant Mill Pond. (Bryant Mill Pond fish are used to represent the composition of PCB that would be expected in the Kalamazoo River if the only source of PCB to the Kalamazoo River was the recycling of paper, because the predominant source of PCB to both the sediments and fish of Bryant Mill Pond was the recycling of paper at the former Allied Paper, Inc. mills.) The peak A trichlorobiphenyls constitute 11% of Aroclor 1242, whereas they comprise only 0.5% of Aroclor 1254 (Schulz et al., 1989). On the other hand, the congeners associated with peak K are prominent in Aroclor 1254, comprising approximately 4% of this mixture while comprising only 0.5% of Aroclor 1242 (Schulz et al., 1989). Peak G has congeners that comprise 8.9% of Aroclor 1254 and 1.6% of Aroclor 1242. For the 1993 Kalamazoo River and Bryant Mill Pond fish samples, PCB congener concentrations were calculated for peaks A, G, and K using peak response factors developed from the response of Aroclor standards run on the RTX-5 column and the mass analyses of Aroclors reported for the SE-54 column by Schulz et al. (1989). Use of other analyses of Aroclors such as that by Frame (1997) would yield similar findings. Ratios of those congener concentrations were calculated and are summarized in Figures 8, 9, and 10.

Figures 8 and 9 present PCB concentration ratios for peaks A/G and peaks A/K, respectively. These two figures illustrate the variations in these ratios and the absence of any significant effect of total PCB concentration on the variability of these ratios. As also evident in Figures 8 and 9, the A/G and A/K ratios of Bryant Mill Pond fish and Morrow Lake fish respectively plot above and below the data for fish collected at Plainwell Dam, Lake Allegan, and Saugatuck on the Kalamazoo River. As qualitatively illustrated and explained earlier in this appendix, the composition of PCB in Kalamazoo River fish is a blending of the Aroclor 1242-like PCB mixture as characterized by Bryant Mill Pond fish and the Aroclor 1254-like mixture as characterized by Morrow Lake fish. In Figure 10, that blending is evident in the average peak PCB concentration ratios for various sections of the Kalamazoo River as ratios falling above those for Morrow Lake and below those for Bryant Mill Pond. This figure also presents the approximate line representing equal (50%/50%) proportions of the Aroclor 1242-derived and Aroclor 1254-derived PCB in fish. Fish plotting above that line would have most of their PCB composition derived from an Aroclor 1242-like mixture and fish plotting below that line would have most of their PCB composition derived from an Aroclor 1254-like mixture. Based upon a review of the PCB chromatograms for fish and this quantitative analysis, roughly

half of the PCB currently found in Kalamazoo River fish are derived from Aroclors other than Aroclor 1242, principally Aroclor 1254.

In contrast to the composition of PCB in fish, Aroclor 1254-derived PCB represents a comparatively smaller proportion of the total mass of PCB in the total volume of PCB-containing sediments of the Kalamazoo River.

Lake Allegan contains approximately 70% of the total PCB mass in the sediments and approximately 44% of the entire river surface of the section of the river from Morrow Lake through Lake Allegan. The PCB quantified by the laboratory as either Aroclor 1254 or Aroclor 1260 comprise approximately 12% of the PCB mass in the sediments of Lake Allegan. There are two reasons that the proportion of Aroclor 1254-derived PCB in the total volume of PCB-containing sediments is much smaller than the proportion of Aroclor 1254-derived PCB in fish. The first reason is that the proportion of Aroclor 1254-derived PCB in the surface sediments, which directly affects PCB bioaccumulation in fish, is much higher than the proportion of Aroclor 1254-derived PCB in the deeper sediments which are no longer influencing PCB concentrations in fish. The second reason, which has been described previously, is that Aroclor 1254 is much more bioaccumulative than Aroclor 1242.

To support this conclusion, Figure 11 presents the chronology of PCB deposition in sediments in Kalamazoo Lake situated near the downstream end of the Kalamazoo River. These cores are the only cores collected downstream of Allegan that have acceptable ^{137}Cs patterns for use in estimating the age of sediment strata. Such cores are generally useful in conducting remedial investigations because they can provide for an assessment of temporal trends where other time series observations are lacking. All three cores exhibit similar significant features with respect to a transition in the relative importance of Aroclor 1254-like PCB. The majority of the total PCB mass in all of the cores is derived from Aroclor 1242 or similar mixtures (i.e., Aroclor 1016, Aroclor 1248). All cores show the trend of steeply declining Aroclor 1242 concentrations in sediments deposited since the mid-1970s to early 1980s. Since the peak in the late 1970s to the early 1980s, concentrations of Aroclor 1242-like PCB have been declining at faster rates than Aroclor 1254-like PCB. The half times for the Aroclor 1254-quantified or Aroclor 1260-quantified PCB in these cores from the late 1970s range from 7.4 years (KL2-1) to 13.3 years (KL2-4), whereas half times for the PCB quantified as the Aroclor 1242-like PCB range from 3.2 years (KL2-1) to 4.6 years (KL2-2). Finally, the proportion of Aroclor 1254-like PCB in surface sediment has been increasing.

For the cores represented on Figure 11, the 1990-93 sediment strata represent 3 to 4 inches of near-surface sediment. Of that, the bioavailable zone is represented by perhaps as little as the top 2 inches of sediment. Within the top 2 inches, Aroclor 1254-like PCB (the laboratory did not quantify any PCB in the top 2 inches of these cores as Aroclor 1260) comprises 23% (cores K2-1, KL2-2) to 31% (core K2-4) of the total PCB mass. Those proportions are much

greater than the proportions in deeper sediments, which, when initially deposited, were formerly in the bioavailable zone. Today, the proportions of the more bioaccumulative Aroclor 1254-like PCB in the bioavailable zone of sediments are consistent with the findings of approximately half of the PCB in fish derived from Aroclor 1254, based upon the differences in the bioaccumulation of Aroclor 1242-like and Aroclor 1254-like PCB. So, the disproportionate levels of Aroclor 1254-like PCB to Aroclor 1242-like PCB in fish with respect to their relative quantities in the total volume of sediment are not only related to the differences in their propensity to bioaccumulate but also are related to the greater proportions of Aroclor 1254-like PCB in bioavailable zone sediment than in the total volume of PCB-containing sediment.

Although the origin and downstream influence of specific point sources of PCB are not apparent from the chromatographic data, it is very clear that sources of PCB that cannot be reasonably attributed to waste paper recycling continue to contribute substantially to the levels of PCB observed in fish. Furthermore, as expected from the scientific information regarding the accumulation of PCB in fish, these other sources contribute proportionately more PCB to the total amount of PCB in fish than they contribute to the total PCB mass in sediment.

Investigation and Remedial Activities at the KRSG Mills and Related Areas

As part of the Kalamazoo River RI, six properties were investigated to assess both the potential for PCB to be released to the river and the presence of PCB in areas where residuals had been stored for disposal. In addition, selected samples were analyzed for polychlorinated dibenzodioxins/dibenzofurans (PCDD/PCDF) and Contract Laboratory Program Target Compound List/Target Analyte List (TCL/TAL) constituents. Remedial efforts at the mills and related areas have consisted of a number of voluntary source-control activities as described below. These voluntary efforts were often performed in advance of the issuance of a Record of Decision (ROD) or Administrative Order by Consent (AOC). Activities were performed with MDEQ oversight and were accompanied by environmental monitoring of water, air, or soils. The remedial work also involved cooperation with local residents. The six properties where voluntary remediation occurred are as follows (figures referenced are in the RI report):

- Former Allied Paper, Inc. Bryant Mill property (Figure 2-1);
- Former King Mill property (Figure 2-2);
- Georgia-Pacific Kalamazoo Mill and property (Figure 1-15);
- Plainwell, Inc. Mill and property (Figure 2-3);
- The King Street Storm Sewer (KSSS) (Figure 1-15); and
- Former Allied Paper Company Monarch Mill (Figure 2-4).

Additional information on the six properties can be found in the DCS (BBEPC, 1992), *Technical Memorandum 1* (BBL, 1994a), and *Technical Memorandum 15* (BBL, 1996c). The mill investigations are briefly described below as well as in Section 2.2 of the RI Report. Descriptions of the investigation and action at each of the OUs follows the mill discussions below (see Section 1.3 of the RI Report for a brief background discussion).

Former Allied Paper, Inc. Bryant Mill (Portage Paper Mill)

The 40-acre former Allied Paper, Inc. Bryant Mill (Portage Paper Mill) property (divided into Mills "C" and "D") is located along Portage Creek (Figure 2-1), approximately 3 miles upstream from its confluence with the Kalamazoo River. Mill C was bordered to the south by Alcott Street, to the north by Bryant Street, to the east by Portage Road, and to the west by Portage Creek. It has been demolished since the start of the RI process. Mill D crosses over the creek and is bordered to the south by Bryant Street, to the north by Reed Street, to the east by Belford Street, and to the west by the railroad tracks. The northern part of the mill property is bordered by residential areas, and commercial and industrial properties border the mill to the southwest, south, and southeast.

No remedial response actions were performed at the former Allied Paper, Inc. Bryant Mill. As directed by the *RI/FS Work Plan* (BBEPC, 1993), several locations at the former Allied Paper, Inc. Bryant Mill were to be sampled to evaluate the presence of PCB associated with the wastewater and process water conveyances. However, the historical residuals were removed from the Bryant clarifier in May 1992. Therefore, when the sampling team and an MDNR representative visited the property to examine the sampling locations identified in the Work Plan and the storm water catchment area sampling location identified in the *Technical Memorandum 1* (BBL, 1994a), it was observed that there were little historical residuals in the proposed sampling locations. As a result, the MDNR determined that it was not necessary to collect samples.

Former King Mill

The former King Mill property, covering approximately 28 acres, is located at 1608 Lake Street in the City of Kalamazoo. The property is bordered by East Vine Street on the north, Clarence Street to the west, Lake Street to the south, and railroad tracks to the east (Figure 2-2). The former King Mill ceased operations in 1971 and was demolished in 1978 by Dore Enterprises (Hager, 1979). Investigation activities were performed to determine the presence of PCB associated with the mill's former lagoons and clarifiers, and to assess whether storm water runoff or drainage from a 48-inch-diameter pipe that originates at the site was a potential contributor of PCB to the river. The results of the investigation indicated the presence of residuals only in the vicinity of the former lagoons; no residuals were associated with the clarifiers or the storm water runoff or drainage. Additional investigation activities

were conducted to further delineate the extent of residuals within the former lagoons. The data collected for the former clarifier and storm water discharge indicated no additional response was necessary at these locations.

In response to the RI activities, voluntary remedial response actions were conducted at the former King Mill consisting of the removal of PCB-containing residuals and soils in two former lagoons (Lagoon EW and Lagoon NS) located east of the former plant. In the fall of 1999, approximately 11,000 cy of residuals were excavated voluntarily from Lagoon EW and disposed of in the King Highway Landfill-OU (KHL-OU). After the residuals were removed, the area was backfilled, graded, and revegetated. Excavation of the lagoons was administered under the KHL-OU AOC (MDEQ, 2000). It is anticipated that additional voluntary removal activities will be undertaken to remove residuals remaining at the property.

Georgia-Pacific Kalamazoo Mill and Property

The Georgia-Pacific Mill property is located in Kalamazoo Township (Figure 1-15). The mill has been operated as a paper-making facility by several different companies since the mid-1800s, and continues to produce paper. Investigation activities were performed to determine the presence of PCB associated with the mill's five former lagoons, the former wastewater treatment system clarifier, storm water runoff at the mill, and the nature and extent of residuals on the property. The results of the investigation indicated the need to further evaluate only the former lagoons, while the data collected at the clarifier and catch basin indicated no additional response was necessary at these locations. Additional investigation activities were conducted to further delineate the extent of residuals within the mill and lagoon area.

In response to the findings of the RI activities, PCB-containing residuals were voluntarily excavated and removed from six former lagoons (Lagoons 1, 2, 3, 3A, 4, and 5; Lagoon 3A was identified during the excavation) on mill property adjacent to the Kalamazoo River that received process wastewater from the mill. Between November 1998 and September 1999, approximately 33,000 cy of residuals were excavated from the lagoons and disposed of in the KHL-OU. After the residuals were removed, the area was backfilled, graded, and revegetated. In addition, PCB-containing materials from the floodplain adjacent to the lagoons were excavated and placed in the KHL-OU. After removing the residuals, that area was also backfilled, graded, and revegetated. Subsequent verification sampling showed compliance with the 9.9 mg/kg criterion established by the MDEQ for the mill lagoons. In addition, approximately 5,000 cy of material were removed from the floodplain from July to September 1999, and placed in the KHL-OU. After excavation, the areas were backfilled and approximately 400 feet of riprap (5 feet wide and 6 inches thick) were placed on top of geotextile along the riverbank. Closure of the lagoons and floodplain is being administered under the KHL-OU AOC (MDEQ, 2000).

Plainwell, Inc. Mill and Property

The 34-acre Plainwell, Inc. Mill is located at 200 Allegan Street in the City of Plainwell (Figure 2-3) and has produced a wide variety of paper products for over 100 years. Historically, residuals from this mill were disposed of at the 12th Street Landfill OU, just downstream of the Plainwell Dam. An investigation of the mill property was performed in 1994 to evaluate the presence of PCB at the former lagoons, the former wastewater treatment system, and the storm water conveyances on the property. The results of the investigation indicated the need to address sediment in storm water Outfall B only. The data collected at the other locations indicated that no response was necessary (BBL, 1996c).

Voluntary remedial response actions at the Plainwell, Inc. Mill consisted of the removal of PCB-containing sediment present in storm water Outfall B. As part of the mill's maintenance, the storm water conveyances were cleared out and the sediment was disposed of properly. Sediment that had collected in a sump along Outfall B was removed in December 1995. Sediment that subsequently accumulated in the sump was sampled in October 1996 and was found to contain PCB at a concentration of 7.2 mg/kg (Brown, 1996). Based upon these results, all drainage pipes leading to Outfall B were cleaned using a high-pressure washer system in November 1997, and the sediment and flush water were appropriately disposed of off site (Cowin, 1998).

KSSS

The approximately 2-acre KSSS property is located adjacent to the western edge of the KHL-OU (Figure 1-15) in the City of Kalamazoo, and consists of the east and west banks of an inlet (approximately 135 feet long) with two culverts at its head. This outfall historically had received wastes and runoff from the former King Mill facility. The results of an investigation conducted in this area indicated a remedial response was necessary. Additional investigation activities were conducted to further delineate the extent of residuals within the KSSS floodplain.

In response to RI results, voluntary remedial response actions at the KSSS consisted of the removal of PCB-containing soils/residuals. In June 1999, approximately 5,000 cy of soils/residuals were excavated from the KSSS and disposed of in the KHL-OU. Subsequent verification sampling showed that the 1 mg/kg clean-up criterion, established for the KSSS area, was achieved. After the materials were removed, the area was backfilled, graded, and revegetated; then about 550 linear feet of riprap (5 feet wide and 6 inches thick) were placed on top of geotextile along the river and outfall channel. The closure of the KSSS is being administered under the KHL-OU AOC (MDEQ, 2000).

Former Allied Paper Company Monarch Mill

The former Monarch Mill property is located southeast of the intersection of Cork Street and the railroad track (Figure 1-4). The property, which was owned and operated by the Allied Paper Company, is bordered to the north by Cork Street, to the west by the railroad bed, and to the south and east by commercial property and light manufacturing facilities. An investigation of the mill property was performed to determine the presence of PCB in the former mill area. The results of the investigation are documented in *Technical Memorandum 15* (BBL, 1996c) and indicated that no additional response was necessary. Based on the results of investigation findings, no voluntary remedial response actions have been undertaken at the former Allied Paper Company Monarch Mill, and no AOC or ROD is anticipated for this Site component.

Investigation and Remedial Response Activities at the OUs

As part of the overall Site investigation, four areas were segregated into Operable Units (OUs). At each OU the RI/FFS process was conducted independently based upon the results obtained during each RI. Voluntary remedial efforts were performed or are planned and consisted of a number of source-control activities. Remedial activities conducted or proposed at each OU are described below.

Allied OU

The 73-acre Allied OU is located along Portage Creek between Alcott and Cork streets in the City of Kalamazoo, Michigan (Figure 1-14). The OU comprises several land-based disposal areas and the former Bryant Mill Pond, a 22-acre area along Portage Creek into which wastewater from the Allied Paper, Inc. operations historically was discharged. Remedial investigation work at the Allied OU is presented in *Technical Memorandum 4 - Results of the Air Investigation* (BBL, 1994c), *Technical Memorandum 7* (BBL, 1997b), *Addendum to Technical Memorandum 7* (BBL, 1999c), and *Draft Technical Memorandum 11* (BBL, 2000). An RI/FS report is anticipated to be prepared for the Allied OU in 2000 that will document findings of the RI, evaluate remedial alternatives, and recommend a preferred remedy for the OU.

Remedial response actions conducted in the 1980s and early 1990s at the Allied OU consisted of the removal and disposal of PCB-containing residuals and sediments, stabilization of disposal area berms along Portage Creek, extraction and treatment of surface water, and construction of a landfill cap over disposal areas occupying approximately 18 acres of the site. An erosion control plan was voluntarily implemented at the former Type III Landfill area of the OU in 1991. This effort included construction of a soil cap, drainage swales, and storm water retention basins; grading of the landfill cap; and seeding with erosion control vegetation. Other voluntary actions

include seeding of the former lagoon areas of the OU to stabilize soils and facilitate evapotransportation in 1991 and 1992. In 1993 and 1995, gabion baskets were installed on either side of Portage Creek to stabilize the berm in the areas of the Bryant Historic Residuals Dewatering Lagoon (HRDL) and Monarch HRDL, respectively.

Pursuant to an agreement with the U. S. Environmental Protection Agency (USEPA) and Millennium Holdings, Inc. (MHI) (USEPA, 1998b), in 1998-99 MHI financed a removal action conducted by the USEPA whereby approximately 150,000 cy of PCB-containing residuals and sediments were excavated from the former Bryant Mill Pond and placed into the land-based disposal areas on site. In accordance with sampling procedures established in the *Final Work Plan - Interim Removal Action at Bryant Mill Pond* (Weston, 1998), approximately 92% of confirmation samples exhibited concentrations of PCB less than 1 mg/kg. Excavated areas were backfilled with an approximately equal volume of clean sand. The residuals and sediments placed into the disposal areas on site were subsequently graded, covered with clean fill, and vegetated with grass.

In January 2000, MHI voluntarily initiated an interim response measure (IRM) to close the disposal areas into which material from the former Bryant Mill Pond had been placed. Consistent with the IRM *Draft Engineering Design Report* (BBL, 1999b), the berm of the disposal areas into which material from the former Bryant Mill Pond was placed was stabilized where it borders Portage Creek with approximately 2,700 linear feet of sheetpile installed near the toe of the berm. The MDEQ has provided assurance to MHI that installation of the sheetpile wall is consistent with what it expects will be the final remedy for the OU (Cornelius, 1999). Groundwater within the sheetpile is being extracted and treated during construction of the IRM. Residuals were removed from soils present between the sheetpile and Portage Creek, and consolidated into the disposal areas. A final cover system consistent with Act 451, Part 115 requirements, including a flexible membrane liner (FML), will be constructed over the disposal areas. Construction of the IRM and the cover system are both expected to be completed by the end of October 2000.

King Highway Landfill OU (KHL-OU)

The 23-acre KHL-OU is located in the City of Kalamazoo and Kalamazoo Township (Figure 1-15). The KHL-OU was originally a series of four settling lagoons that were used to dewater residuals from the Georgia-Pacific Kalamazoo Paper Mill. In 1983, the MDNR licensed three of the lagoons as a Type III landfill. From 1987 to 1996, the KHL received dewatered residuals from the mill's belt-filter presses.

Remedial investigation activities and results are presented and summarized in *Technical Memorandum 6 - KHL-OU* (BBL, 1994b) and the *Remedial Investigation Report* (BBL, 1994e). The *Final Submittal in Support of the Remedial Investigation/Focused Feasibility Study - KHL-OU* (BBL, 1997a) was submitted to the MDEQ in 1997. Additional supporting documentation included *Draft Addendum 1 to the Remedial Investigation Report - Cell 4 Investigation*

(BBL, 1995b) and *Addendum 2 to the Remedial Investigation Report - Additional Groundwater Sampling* (BBL, 1996a). A Feasibility Study (FS) was conducted and presented in the *Focused Feasibility Study* (FFS) Report (BBL, 1994f). A ROD for the KHL-OU was signed in 1998 (USEPA, 1998a); the remedy selected in the ROD included containment via capping following the consolidation of select residuals/soils/sediments.

Remedial response actions consistent with the KHL-OU ROD began in 1996 and are anticipated to be completed in 2000. As part of the remedy, PCB-containing sediments identified in the river adjacent to the KHL-OU were removed during August and September 1999. Approximately 6,000 cy of sediments were excavated from the northern edge of the KHL-OU and disposed of in Cell 4 of the KHL-OU, while approximately 5,000 cy were removed from within the perimeter berm behind the sheetpile wall, and 1,000 cy were removed from in front of the sheetpile wall. After the materials in front of the sheetpile wall were removed, approximately 700 linear feet of riprap (5 feet wide and 6 inches thick) were placed on top of geotextile along the sheetpile wall. The area behind the sheetpile wall was backfilled and revegetated along with the landfill. As part of the consolidation efforts, the KHL-OU received approximately 95,000 cy of residuals from the northern edge of the OU, the KSSS, the former King Mill, and the Georgia-Pacific Mill Lagoons. In addition, dike-stabilization and erosion-control measures were implemented along the perimeter of the OU. Appropriate long-term institutional controls and maintenance are also part of the selected remedy. Construction of the Part 115, Type III landfill cap is complete. Closure of the KHL-OU is being administered by the Remedial Design/Remedial Action (RD/RA) AOC finalized in February 2000 (MDEQ, 2000).

Willow Boulevard/A-Site OU (WB/A-OU)

The 32-acre WB/A-OU is located in Kalamazoo Township, in the Lakewood neighborhood (Figure 1-16). The OU consists of the Willow Boulevard Site, A-Site, and the area east of Davis Creek. Davis Creek runs along the eastern edge of the A-Site, and Olmstead Creek separates the Willow Boulevard Site from the A-Site and runs along the southern edge of the A-Site. The Willow Boulevard Site and A-Site received residuals from the Georgia-Pacific Kalamazoo Mill and predecessors. In addition, the area east of Davis Creek received some residuals from the A-Site, which was originally a series of dewatering lagoons used by the King Mill.

Remedial investigation activities at the WB/A-OU are presented and summarized in *Technical Memorandum 5 - Results of the Air Investigation* (BBL, 1994d), *Technical Memorandum 9* (BBL, 1995a), and *Draft Addendum to Technical Memorandum 9* (BBL, 1996b). A *Draft Remedial Investigation/Focused Feasibility Study* (RI/FFS) for the OU was prepared and submitted to the MDEQ in July 1999 (BBL, 1999a) and is currently undergoing review. The total amount of residuals associated with the OU is approximately 640,000 cy; the Willow Boulevard Site and A-Site contain an estimated 150,000 cy and 480,000 cy of residuals, respectively. The area east of Davis Creek has

an estimated 3,800 cy of residuals, and the area south of the A-Site berm has an estimated 2,900 cy of residuals. Based on the results of the initial investigation activities, additional voluntary investigation activities were conducted on the Adkins and Wadsworth properties south of the A-Site, and on the Wright and Bloomfield properties in the AMW-3A area. No residuals were found on the Adkins and Wadsworth properties. At the Wadsworth properties, one out of nine samples had detectable PCB at a concentration of 0.12 mg/kg. Average surficial PCB concentration on the Wright property was 0.85 mg/kg, and the average surficial PCB concentration on the Bloomfield property was 0.42 mg/kg.

Sheetpiling installed at the A-Site as an IRM extended about 2,000 feet along the Kalamazoo River and 150 feet along Davis Creek. This wall was installed to an elevation 2 feet above the 100-year flood elevation (767 feet). As an additional interim remedial action, PCB-containing sediments along the western bank of the Willow Boulevard Site and the Olmstead Creek confluence with the Kalamazoo River were excavated. From November 1999 to January 2000, approximately 7,000 cy of sediments were excavated and disposed of at the Willow Boulevard Site; approximately 6,700 cy were excavated from the western bank, and 300 cy were removed from Olmstead Creek confluence. Upon completion of the excavation activities, the bank of the Willow Boulevard Site was stabilized with geotextile and riprap. The disposal area at the Willow Boulevard Site was graded and temporarily capped with a 6-inch-thick sand layer.

12th Street Landfill OU

The approximately 6.5-acre 12th Street Landfill OU is located 1.5 miles northwest of the City of Plainwell (Figure 1-17). RI activities at the 12th Street Landfill OU are presented and summarized in *Technical Memorandum 0* (Geraghty & Miller, 1994a), *Technical Memorandum 8* (Geraghty & Miller, 1994b), and *Remedial Investigation Report* (Geraghty & Miller, 1996). Approximately 1,600 cy of PCB-containing soils are present in wetlands north and west of the landfill, and an undetermined volume of residuals is present in the Kalamazoo River immediately east of the landfill.

Voluntary remedial response actions at the 12th Street Landfill OU conducted to date consist of the placement of 1 to 7 feet of topsoil over the landfill, and seeding to establish vegetation in 1984. The selected remedy for the OU, which was presented in the *Focused Feasibility Study Report* (Geraghty & Miller, 1997), includes excavation, consolidation, and on-site containment of PCB-containing soils and residuals into the existing 200,000-cy landfill. A Proposed Plan was completed in 1997, while a ROD is awaited from MDEQ.

A voluntary IRM has been proposed for the 12th Street Landfill OU consistent with the ROD that is expected to be issued. For the IRM, PCB-containing soils and residuals in the adjacent wetlands would be removed and consolidated

onto the landfill. Residuals in the Kalamazoo River that are visibly contiguous with the landfill would be removed from the river and placed on the landfill. Following consolidation of these materials and regrading of the landfill to promote proper drainage, a final cover system consistent with Act 451, Part 115 requirements would be constructed over the landfill. In addition, stabilization and erosion-control measures would be implemented along the river perimeter of the landfill to reduce the potential mobility of residuals to the Kalamazoo River. Appropriate long-term institutional controls and maintenance would be implemented with the selected remedy. The ROD for the OU is expected to be signed during the second half of 2000.

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Table

TABLE 1

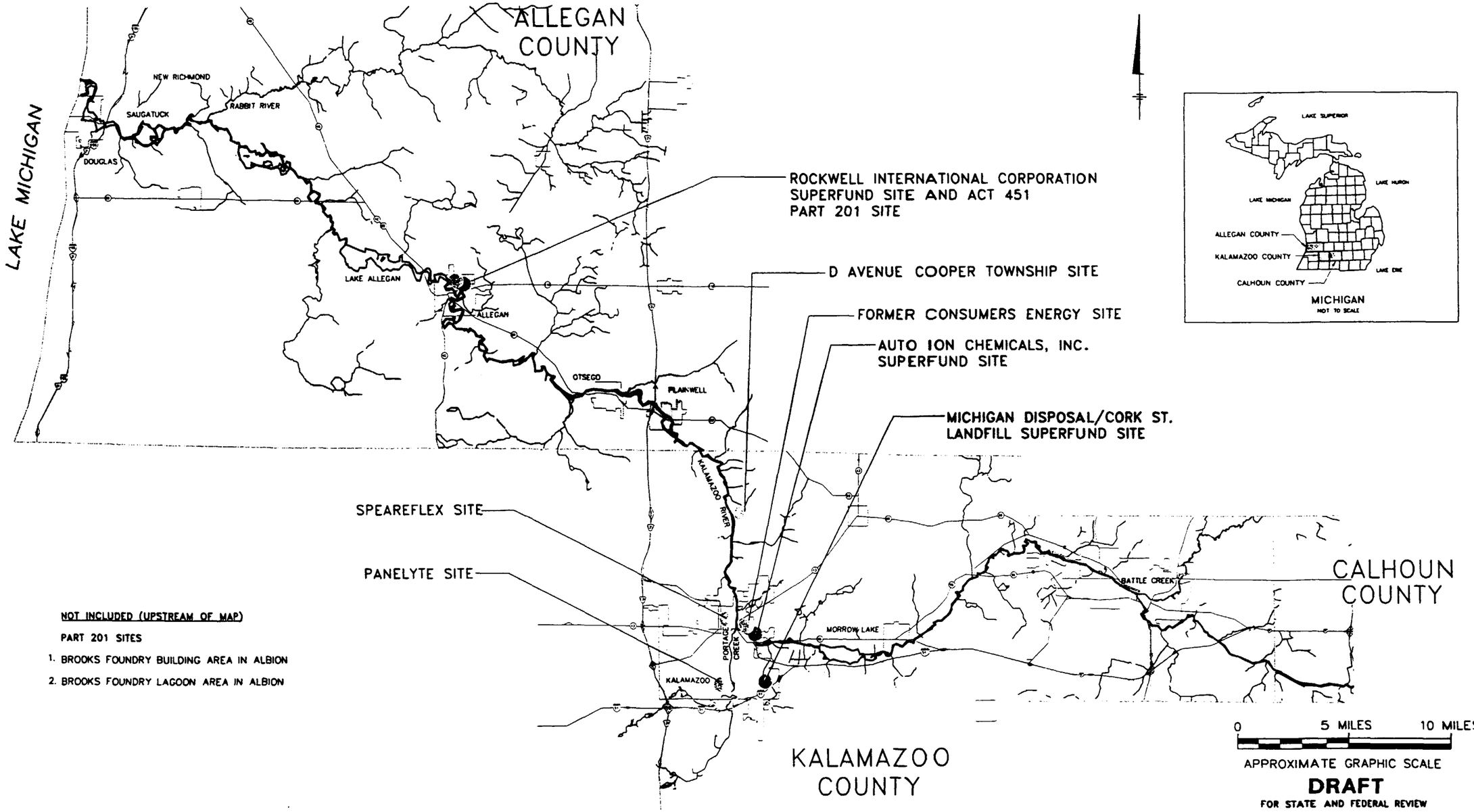
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

REMEDIAL INVESTIGATION REPORT
RATIO OF AROCLOR 1242 TO AROCLOR 1254 BY REACH IN
KALAMAZOO RIVER SEDIMENT

Kalamazoo River Sediment > 1 mg/kg							
Description	**N**	**Median**	**Range**	**5th Percentile**	**10th Percentile**	**90th Percentile**	**95th Percentile**
Morrow Lake							
Morrow Dam to Portage Creek Confluence	9	1.8	0 to >20	0	0	>20	>20
Portage Creek Confluence to Main Street, Plainwell	18	3.7	0.45 to >20	0.45	2.0	>20	>20
Main Street, Plainwell to Plainwell Dam	17	6.3	1.2 to >20	1.0	1.5	>20	>20
Plainwell Dam to Otsego City Dam	20	5.8	1.3 to >20	1.3	2.0	>20	>20
Otsego City Dam to Otsego Dam	15	2.0	0 to 7	0	0.33	7	7
Otsego Dam to Trowbridge Dam	17	3.3	1.0 to >20	0.90	1.0	>20	>20
Trowbridge Dam to Allegan City Line	22	2.9	1.1 to >20	1.1	1.2	>20	>20
Allegan City Line to Allegan City Dam	33	6.7	0 to >20	1.2	1.5	>20	>20
Allegan City Dam to Allegan Dam	70	6.2	1.2 to >20	1.7	3.0	12.4	>20
Portage Creek	66	>20	0 to >20	1.5	4.4	>20	>20

Notes:
Includes only those samples with PCB concentrations greater than 1.0 mg/kg and where 60% or more of the total PCB is the sum of Aroclors 1242 and 1254.
Percentiles were extrapolated where necessary and should be considered estimates only.

Figures



NOT INCLUDED (UPSTREAM OF MAP)

PART 201 SITES

1. BROOKS FOUNDRY BUILDING AREA IN ALBION
2. BROOKS FOUNDRY LAGOON AREA IN ALBION

LEGEND

- SUPERFUND SITE
- ACT 451 PART 201 SITE

NOTES:

1. ALLEGAN, KALAMAZOO AND CALHOUN COUNTY MAPPING OBTAINED FROM MICHIGAN RESOURCE INFORMATION SYSTEM.
2. ALL LOCATIONS ARE APPROXIMATE.

DRAFT

FOR STATE AND FEDERAL REVIEW

KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

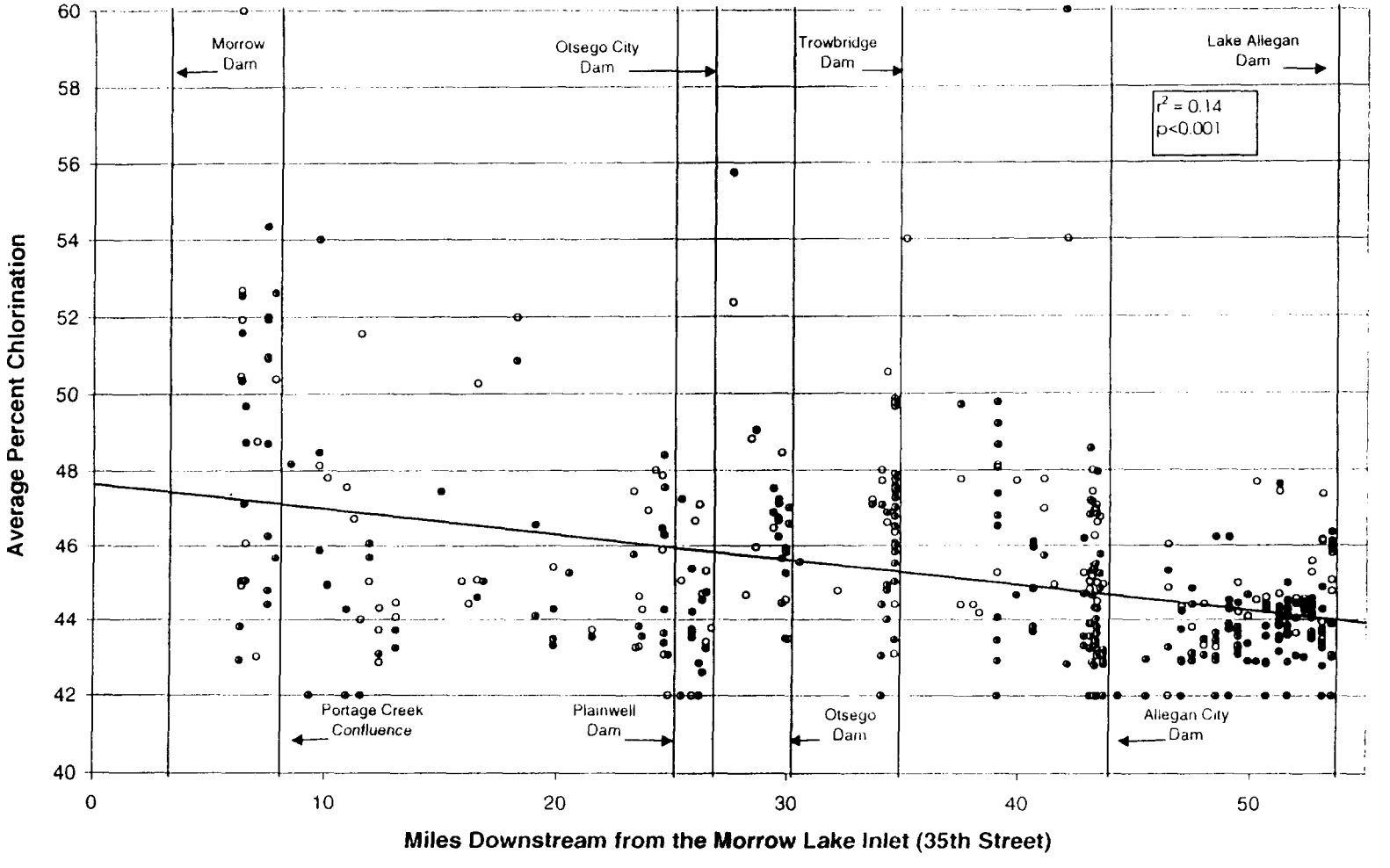
REMEDIAL INVESTIGATION REPORT

SUPERFUND SITES AND ACT 451 PART 201 SITES WITH PCB ISSUES

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE 1

X: 64524X00.DWG
L: ON=*;OFF=REF
P: STD-PCP/BL
10/23/00 SYR-54-CBM MES KMD
64524500/APPEND/64524G01.DWG



LEGEND

- ○ Surface
- ● Subsurface

NOTE:
All samples with PCB > 1 mg/kg (n=445)

DRAFT FOR STATE AND FEDERAL REVIEW

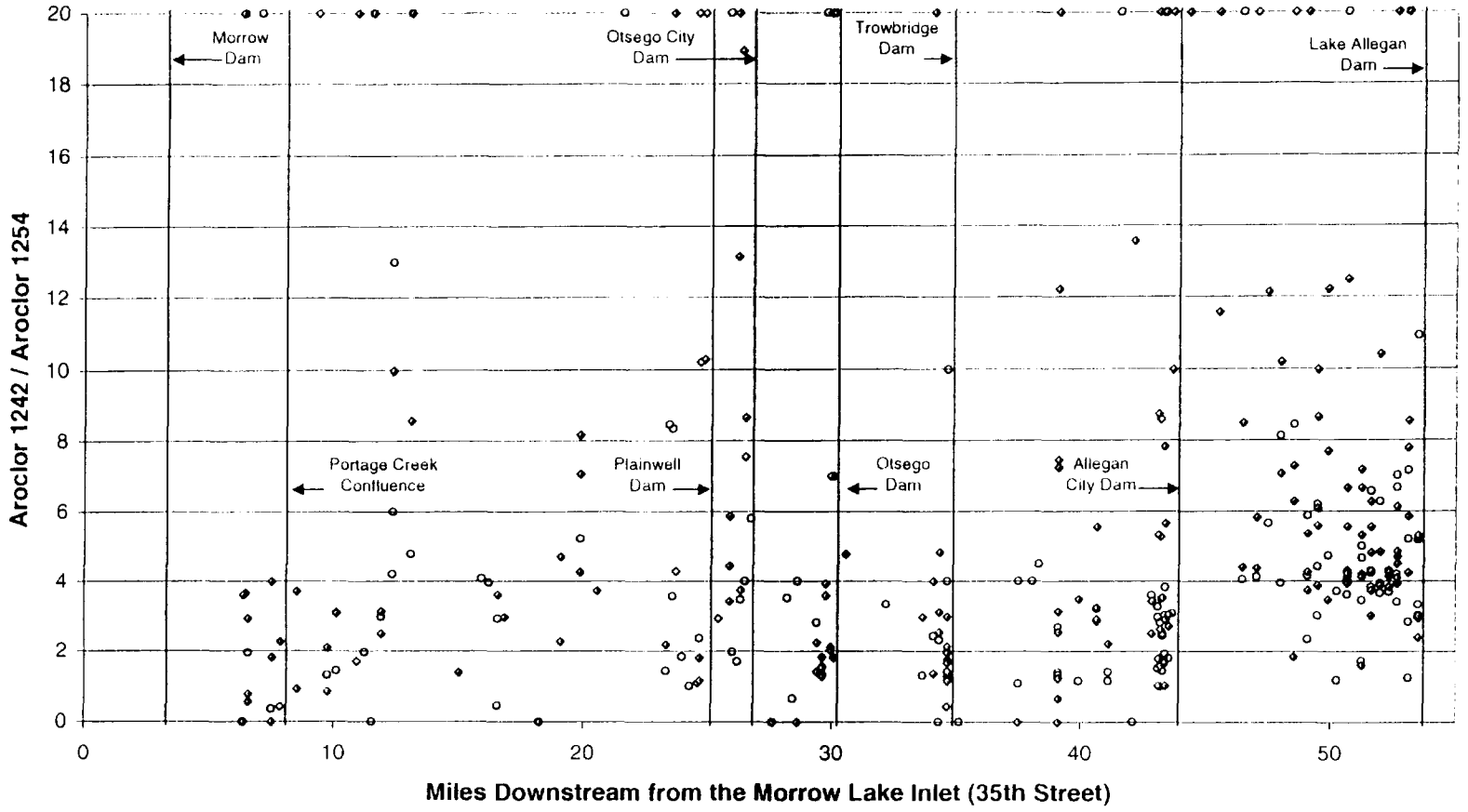
KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

REMEDIAL INVESTIGATION REPORT

DOWNSTREAM TREND IN AVERAGE PERCENT CHLORINATION OF DETECTED PCB

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE 2



LEGEND

- ○ Surficial < 10 mg/kg
- ● Surficial > 10 mg/kg
- ◇ Subsurface <10 mg/kg
- ◆ Subsurface >10 mg/kg

NOTES:

1. All samples >1 mg/kg total PCB, by transect.
2. A ratio of 20 indicates those samples that are 95% or more Aroclor 1242 and 5% or less Aroclor 1254

DRAFT FOR STATE AND FEDERAL REVIEW

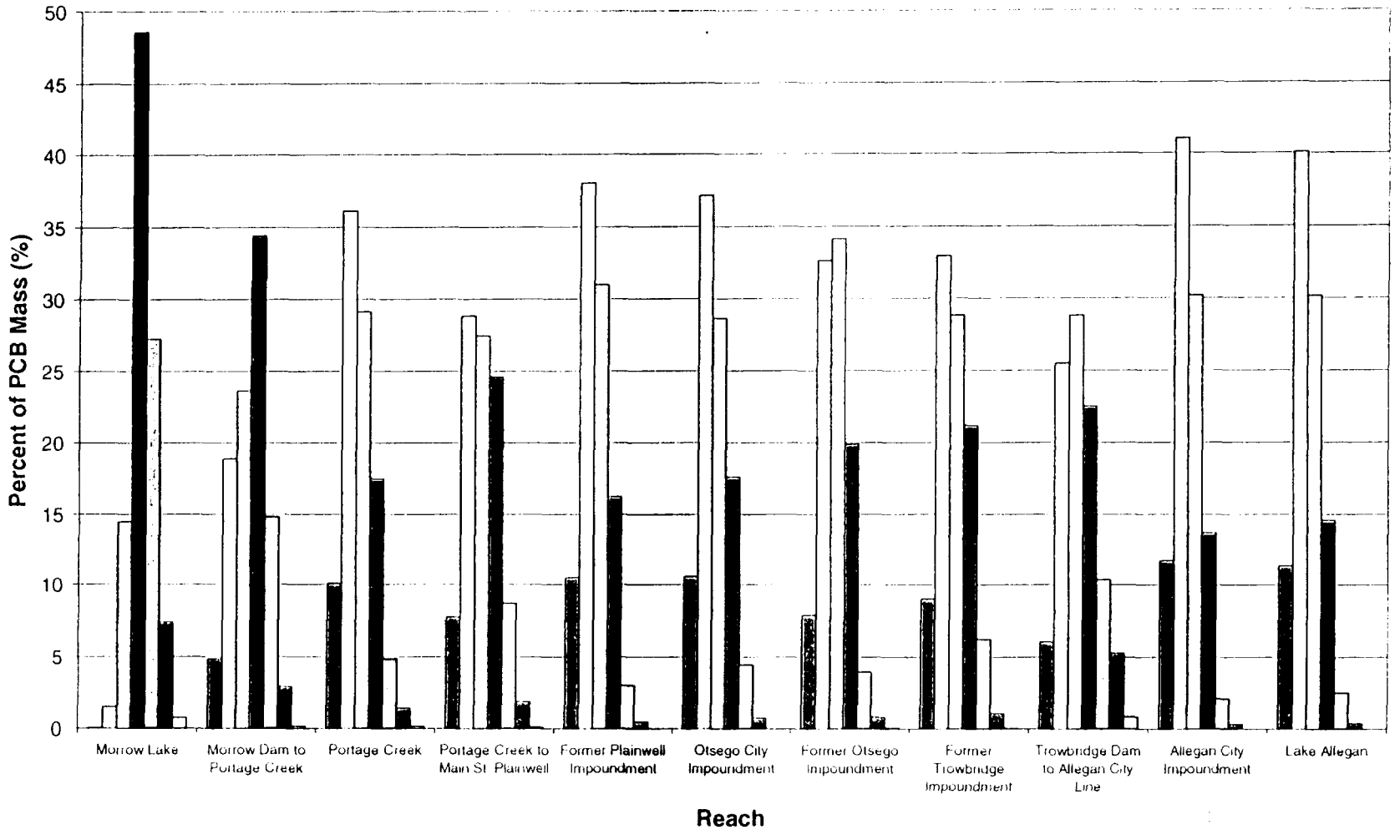
KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

REMEDIAL INVESTIGATION REPORT

RATIO OF AROCLOR 1242 TO AROCLOR 1254 IN KALAMAZOO RIVER SEDIMENT

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE 3



NUMBER OF CHLORINES

■2 □3 □4 ■5 □6 ■7 □8

NOTE:
Homologs with one and nine chlorines contributed less than one percent of the total PCB concentration and are not shown.

DRAFT FOR STATE AND FEDERAL REVIEW

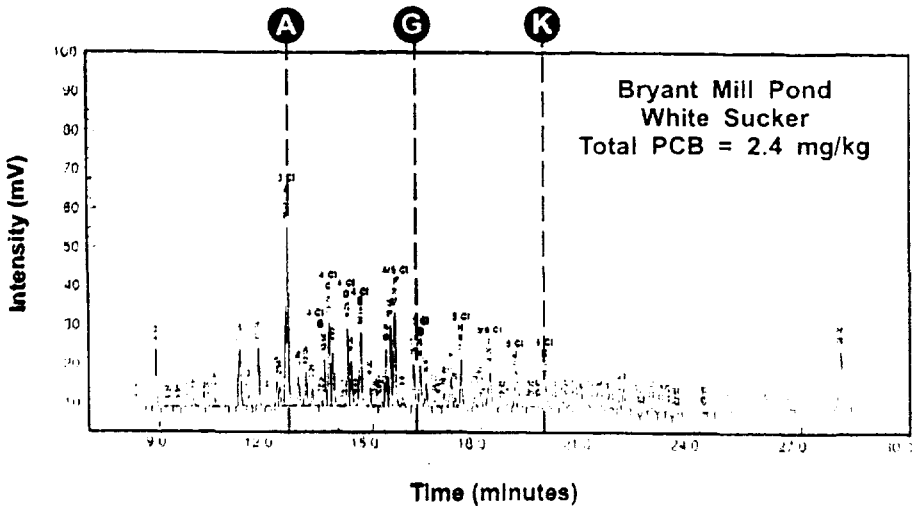
KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

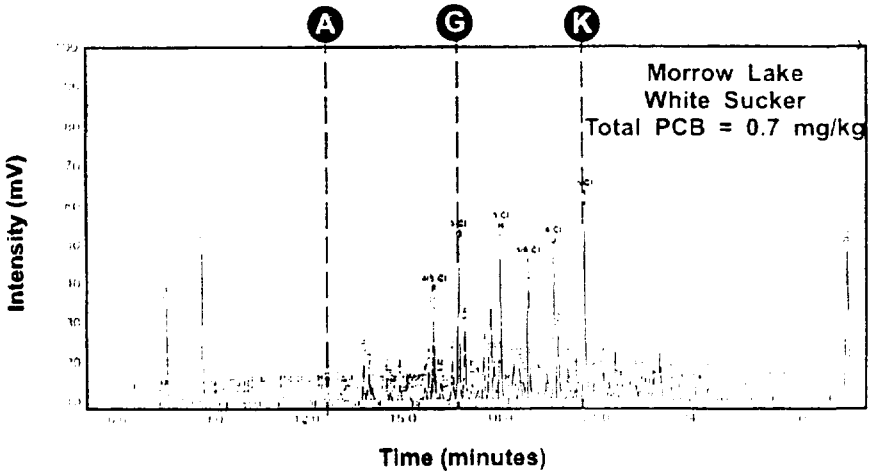
REMEDIAL INVESTIGATION REPORT

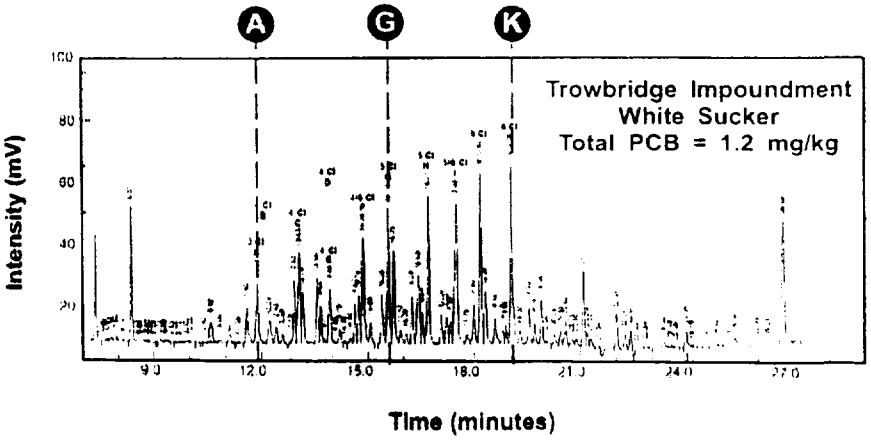
SEDIMENT PCB HOMOLOG DISTRIBUTION

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE 4







NOTE:
Peak A = 2, 4', 5 & 2, 4, 4'-Trichlorobiphenyls
Peak G = 2, 2', 3, 4', 5 & 2, 2', 4, 5, 5'-Pentachlorobiphenyls
Peak K = 2, 3, 3', 4, 5, 6 & 2, 2', 3, 4, 4', 5' &
2, 3, 3', 4, 4', 6-Hexachlorobiphenyls

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08/00 SYR-054 -DJH LBR
64524500/64524n32.CDR

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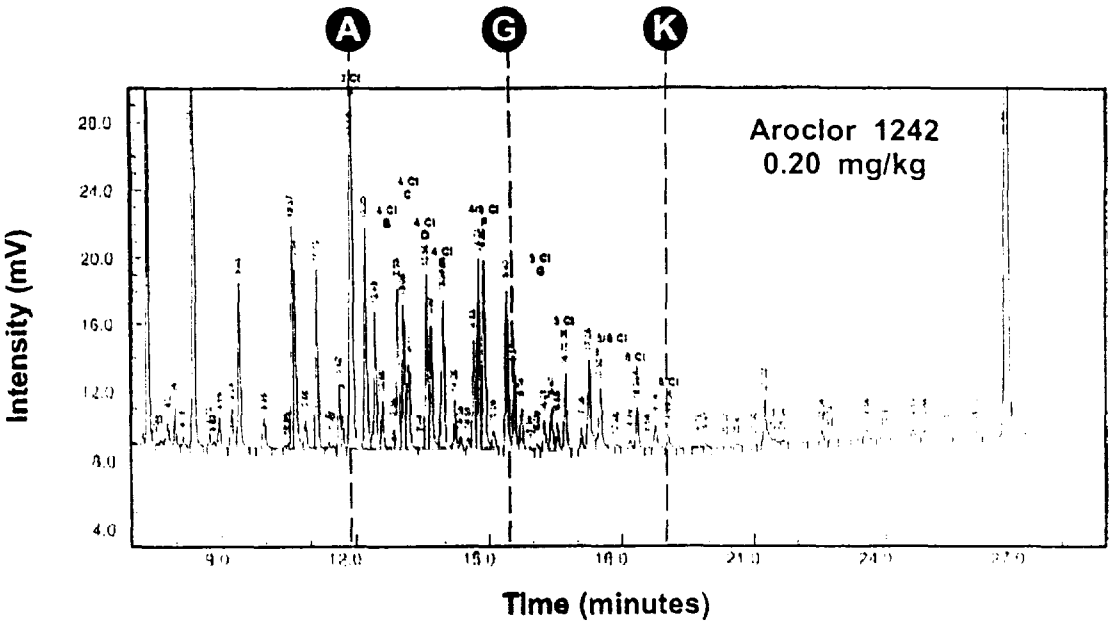
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

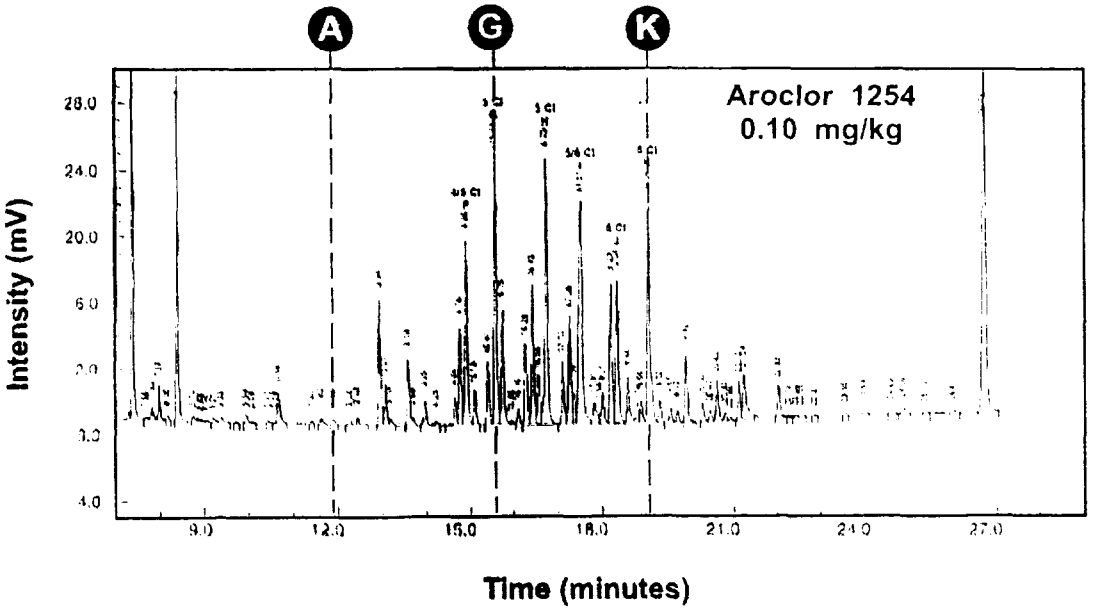
REMEDIAL INVESTIGATION REPORT

CHROMATOGRAMS OF PORTAGE CREEK AND KALAMAZOO RIVER FISH SAMPLES

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 5





NOTE:
Peak A = 2, 4', 5 & 2, 4, 4'-Trichlorobiphenyls
Peak G = 2, 2', 3, 4', 5 & 2, 2', 4, 5, 5'-Pentachlorobiphenyls
Peak K = 2, 3, 3', 4, 5, 6 & 2, 2', 3, 4, 4', 5' &
2, 3, 3', 4, 4', 6-Hexachlorobiphenyls

08/00 SYR-D54 -DJH LBR
64524500/64524n33.CDR

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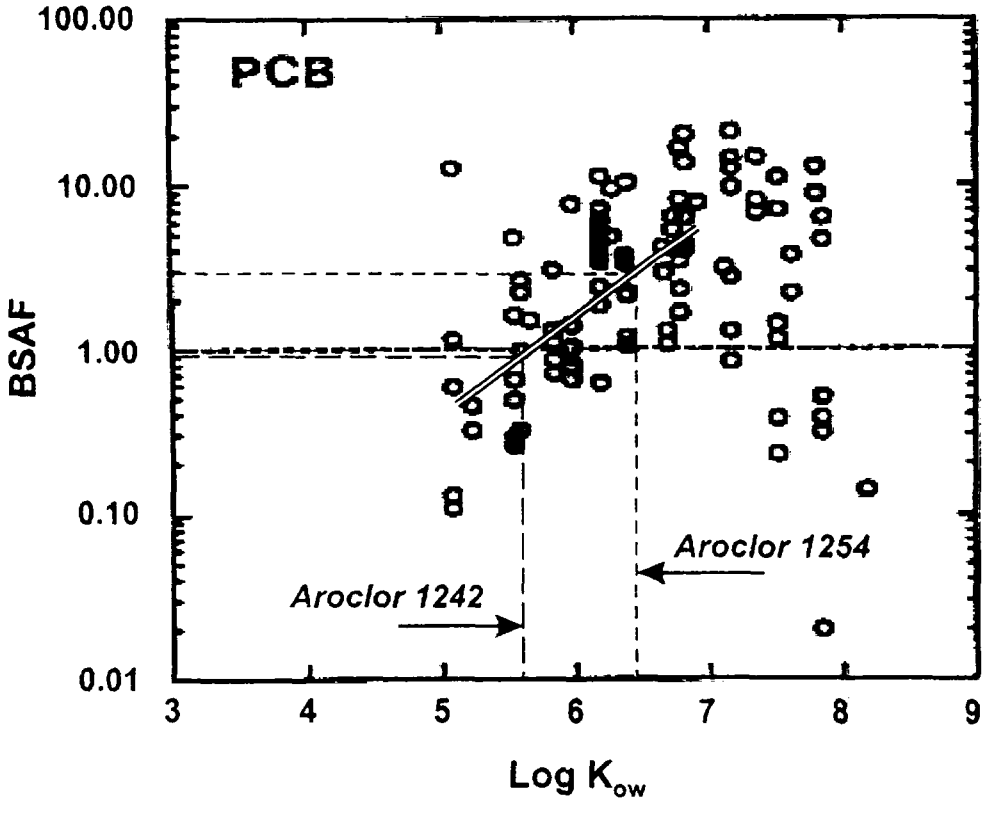
REMEDIAL INVESTIGATION REPORT

AROCLOR 1242 AND AROCLOR 1254 STANDARD CHROMATOGRAMS

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 6



REFERENCE: Parkerton et al., 1993

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REMEDIAL INVESTIGATION REPORT

RELATIONSHIP BETWEEN BSAF AND LOG K_{ow}

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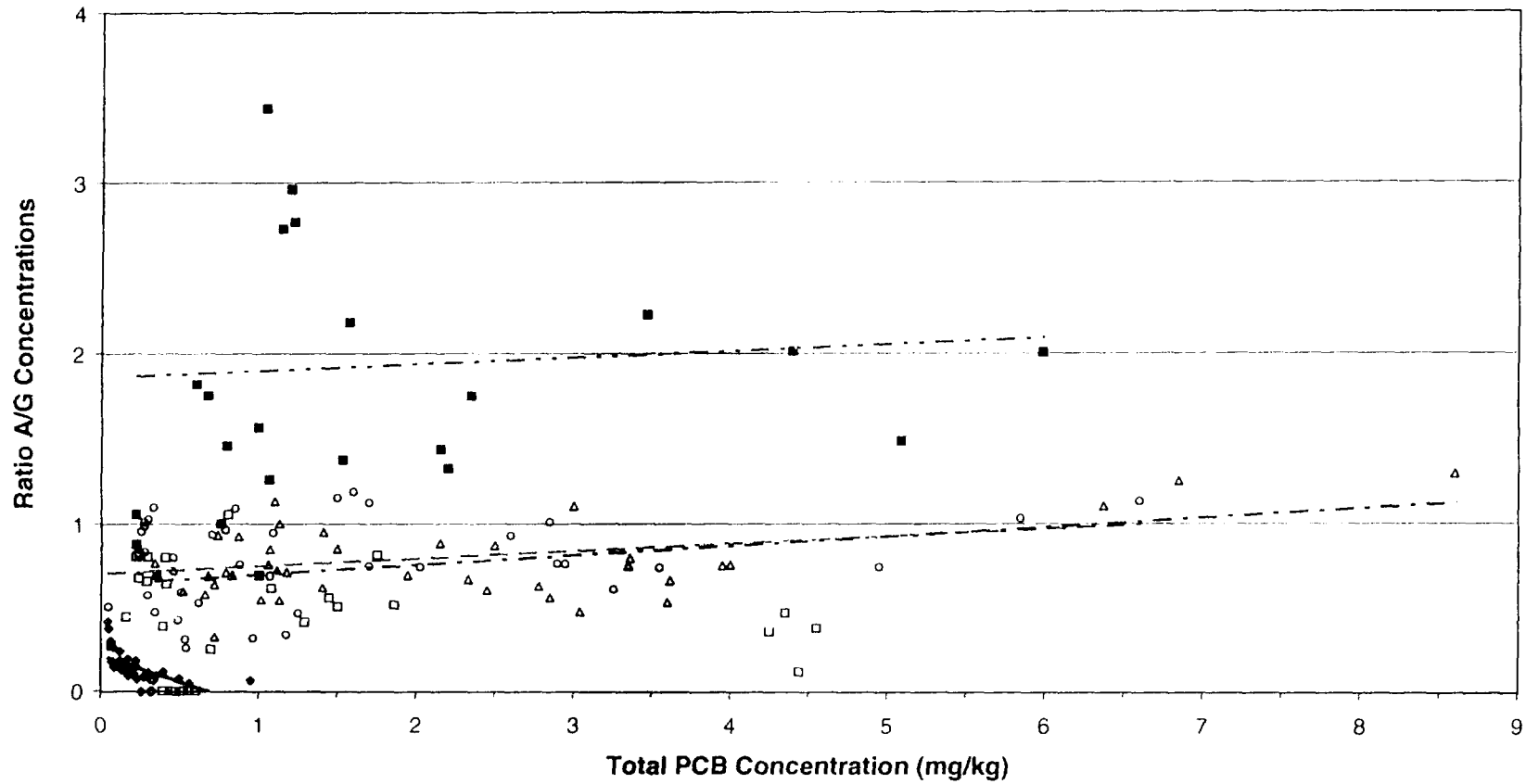
BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE 7

08/00 SYR-D54-DJH
64524500/64524n51.CDR



LEGEND

- Morrow Lake
- Bryant Mill Pond
- Lake Allegan
- Plainwell Dam
- Near Saugatuck

Linear Regression Line - Morrow Lake ($r^2 = 0.34$)
Linear Regression Line - Bryant Mill Pond ($r^2 = 0.0025$)
Linear Regression Line - Lake Allegan ($r^2 = 0.069$)
Linear Regression Line - Plainwell Dam ($r^2 = 0.24$)
Linear Regression Line - Near Saugatuck ($r^2 = 0.0047$)

NOTE:
Peak A = 2,4',5 & 2,4,4'-Trichlorobiphenyls
Peak G = 2,2',3,4',5 & 2,2',4,5,5'-Pentachlorobiphenyls

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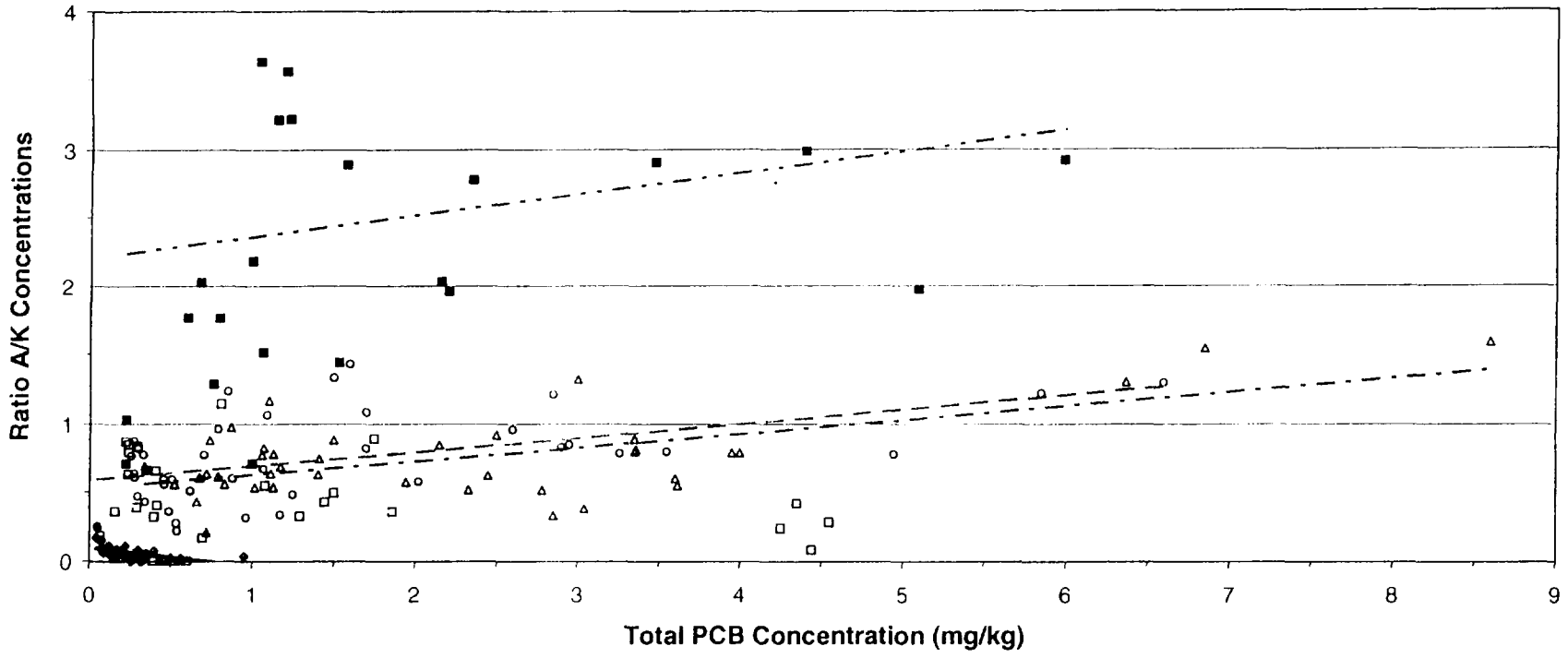
REMEDIAL INVESTIGATION REPORT

A/G PCB CONCENTRATION RATIO VS TOTAL PCB - 1993 FISH DATA

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE 8



LEGEND

- Morrow Lake
- Bryant Mill Pond
- Lake Allegan
- Plainwell Dam
- Near Saugatuck
- Linear Regression Line - Morrow Lake ($r^2 = 0.25$)
- Linear Regression Line - Bryant Mill Pond ($r^2 = 0.017$)
- Linear Regression Line - Lake Allegan ($r^2 = 0.26$)
- Linear Regression Line - Plainwell Dam ($r^2 = 0.38$)
- Linear Regression Line - Near Saugatuck ($r^2 = 0.010$)

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NOTE:
Peak A = 2,4',5 & 2,4,4'-Trichlorobiphenyls
Peak K = 2,3,3',4,5,6 & 2,2',3,4,4',5' & 2,3,3',4,4',6-Hexachlorobiphenyls

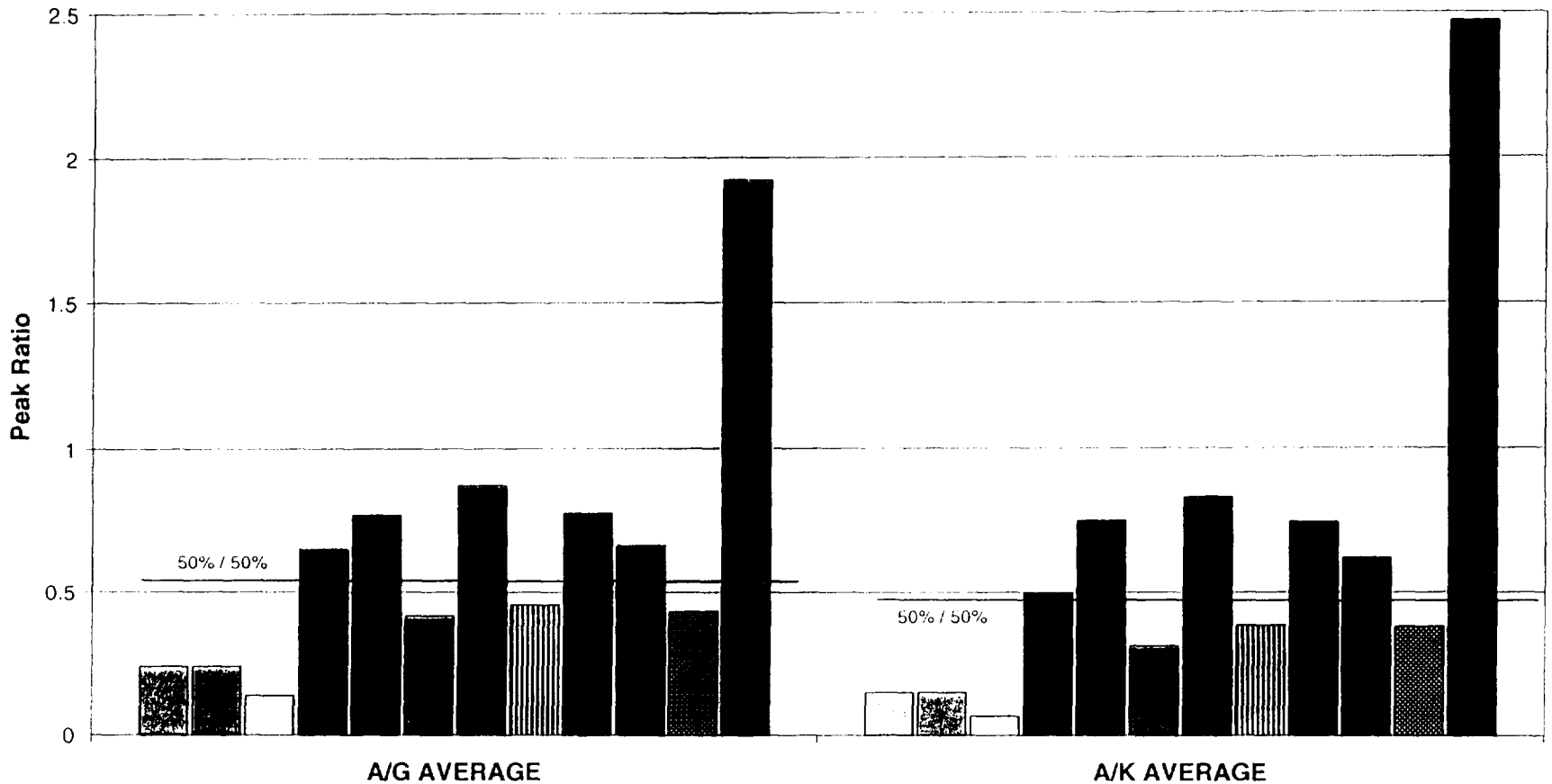
KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC /PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

REMEDIAL INVESTIGATION REPORT

A/K PCB CONCENTRATION RATIO VS TOTAL PCB - 1993 FISH DATA

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE 9



LEGEND

- Upstream of Battle Creek
- Downstream of Morrow Lake
- Plainwell Dam
- Otsego Dam
- Lake Allegan
- Near Saugatuck
- Morrow Lake
- Near Mosel Ave
- Otsego City Impoundment
- Trowbridge Dam
- Downstream of Lake Allegan
- Bryant Mill Pond

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NOTE:
Peak A = 2,4',5 & 2,4,4'-Trichlorobiphenyls
Peak G = 2,2',3,4',5 & 2,2',4,5,5'-Pentachlorobiphenyls
Peak K = 2,3,3',4,5,6 & 2,2',3,4,4',5' & 2,3,3',4,4',6-Hexachlorobiphenyls

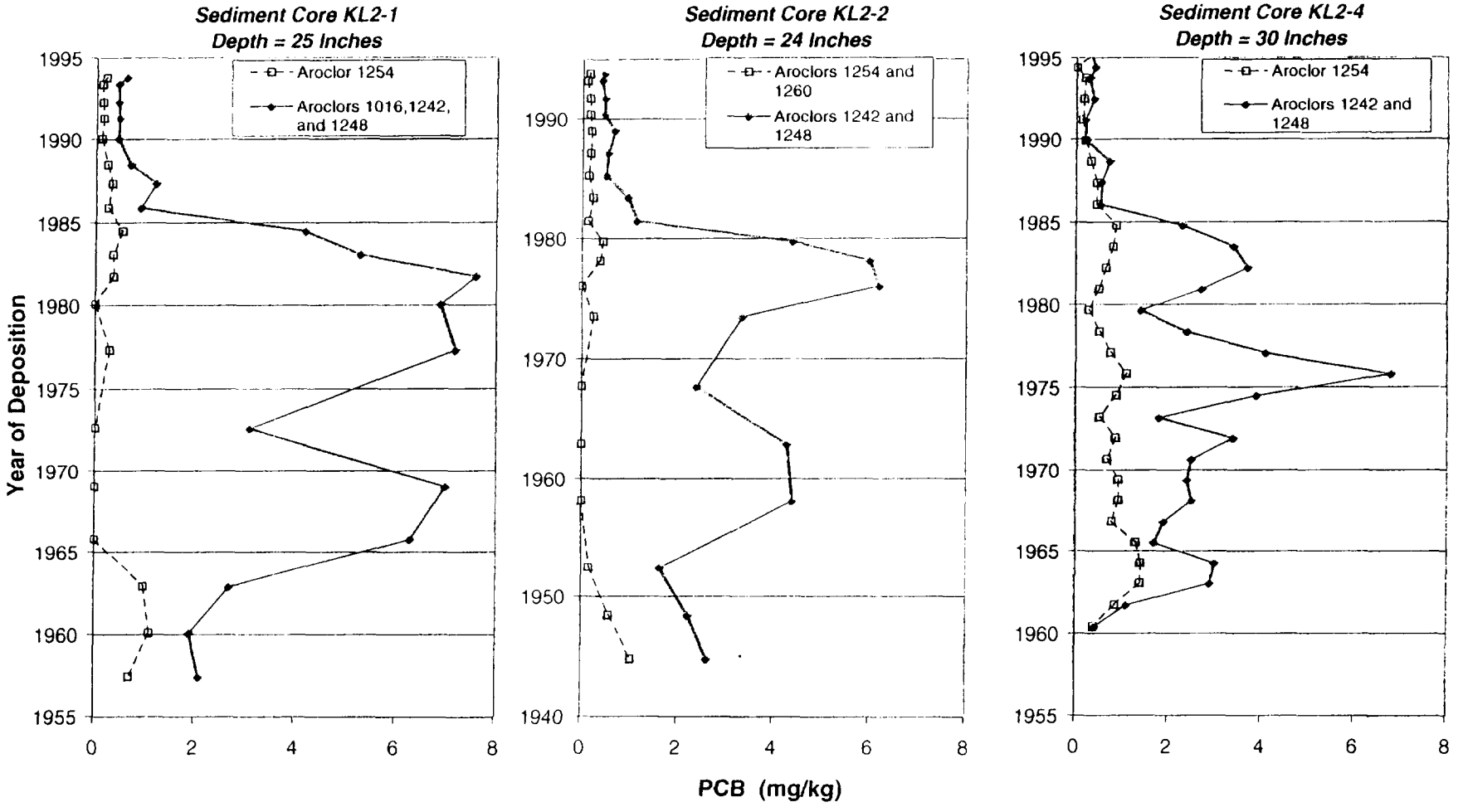
KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC /PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

REMEDIAL INVESTIGATION REPORT

PCB CHROMATOGRAM PEAKS A/G AND A/K PCB CONCENTRATION RATIO AVERAGES - 1993 FISH DATA

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 10



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KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC /PORTAGE CREEK/KALAMAZOO RIVER SUPERFUND SITE

REMEDIAL INVESTIGATION REPORT

PCB DEPOSITION CHRONOLOGIES FROM CORES COLLECTED IN KALAMAZOO LAKE

BBL BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

FIGURE 11

Table 1

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish by Aquatic Biota Sampling Area

Species/ Location	Year	Number of Samples	Concentration-weighted fraction of total (percent)				
			Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Discrete Fillet Samples							
BLACK CRAPPIE							
Lake Allegan	1999	1	0.0	31	35	34	0.0
BLUEGILL SUNFISH							
Plainwell Dam to Otsego City Dam	1999	10	0.0	25	8.7	67	0.0
Upstream of Trowbridge Dam	1999	11	0.0	36	21	43	0.0
Lake Allegan	1999	8	0.0	35	12	50	3.0
CARP							
Near Battle Creek	1993	11	0.0	0.0	0.0	62	38
	1997	11	0.0	0.0	0.0	83	17
	All Years	22	0.0	0.0	0.0	73	27
Morrow Lake	1993	11	0.0	0.0	0.0	66	34
	1997	10	0.0	0.0	0.0	60	40
	1999	11	0.0	0.0	0.0	89	11
	All Years	32	0.0	0.0	0.0	73	27
Upstream of Portage Creek	1993	11	0.0	0.0	0.0	83	17
Near Mosel Avenue in Kalamazoo	1993	11	18	3.6	0.0	72	5.9
	1999	11	0.0	7.0	31	54	7.4
	All Years	22	9.1	5.3	16	63	6.6
Upstream of Plainwell Dam	1993	11	0.0	17	42	38	2.9
	1997	11	0.0	0.9	58	38	3.7
	1999	11	0.0	0.0	60	35	5.3
	All Years	33	0.0	4.9	54	37	4.2
Plainwell Dam to Otsego City Dam	1993	11	4.5	2.9	17	62	13
Upstream of Otsego Dam	1993	11	7.5	23	16	51	2.8
Upstream of Trowbridge Dam	1993	11	3.8	0.0	33	54	9.9
	1999	11	0.0	18	30	46	5.5
	All Years	22	2.4	6.8	32	51	8.3
Lake Allegan	1993	11	0.0	0.0	44	51	5.9
	1997	11	0.0	0.0	22	63	15
	1999	11	0.0	2.5	29	57	12
	All Years	33	0.0	1.0	34	55	9.8
Swan Creek Marsh	1993	11	0.0	0.0	27	61	12
Near New Richmond	1993	11	0.0	0.0	4.0	88	7.6
	1997	12	0.0	5.3	13	70	11
	1999	11	0.0	0.0	33	58	8.5
	All Years	34	0.0	2.0	15	74	9.2

(See notes on page 5)

Table 1

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish by Aquatic Biota Sampling Area

Species/ Location	Year	Number of Samples	Concentration-weighted fraction of total (percent)				
			Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Portage Creek (Bryant Mill Pond)	1993	11	0.0	0.0	87	6.0	7.0
Near Saugatuck	1999	11	0.0	3.6	34	56	6.3
CHANNEL CATFISH							
Plainwell Dam to Otsego City Dam	1999	2	0.0	0.0	0.0	74	26
Upstream of Trowbridge Dam	1999	3	0.0	16	15	59	11
Lake Allegan	1999	11	0.0	6.9	3.1	61	29
Near New Richmond	1999	1	0.0	0.0	54	46	0.0
Near Saugatuck	1999	4	0.0	0.0	0.0	71	29
NORTHERN PIKE							
Plainwell Dam to Otsego City Dam	1999	2	0.0	0.0	48	47	5.5
Upstream of Trowbridge Dam	1999	2	0.0	8.6	10	66	15
Lake Allegan	1999	11	0.0	9.9	3.0	79	8.5
Near New Richmond	1999	4	0.0	0.0	39	55	5.8
Near Saugatuck	1999	4	0.0	0.0	44	53	3.5
PUMPKINSEED SUNFISH							
Near Mosel Avenue in Kalamazoo	1999	11	0.0	17	17	65	0.7
Lake Allegan	1999	3	0.0	36	11	52	0.0
SMALLMOUTH BASS							
Near Battle Creek	1993	11	0.0	0.0	0.0	76	24
	1997	10	0.0	0.0	0.0	86	14
	All Years	21	0.0	0.0	0.0	78	22
Morrow Lake	1993	11	0.0	0.0	0.0	76	24
	1997	11	0.0	0.0	0.0	85	15
	1999	11	0.0	0.0	3.2	88	8.9
	All Years	33	0.0	0.0	1.2	82	17
Upstream of Portage Creek	1993	11	0.0	0.0	0.0	85	15
Near Mosel Avenue in Kalamazoo	1993	11	16	6.4	0.0	60	18
	1999	11	0.0	2.4	6.5	80	11
	All Years	22	6.7	4.1	3.8	71	14
Upstream of Plainwell Dam	1993	11	19	1.8	16	58	5.6
	1997	11	0.0	4.1	21	64	10
	1999	11	0.0	1.3	29	60	10
	All Years	33	12	2.1	19	59	7.2
Plainwell Dam to Otsego City Dam	1993	11	11	0.0	2.0	71	16
	1999	11	0.0	3.0	34	55	7.4
	All Years	22	5.2	1.5	19	63	12

(See notes on page 5)

Table 1

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish by Aquatic Biota Sampling Area

Species/ Location	Year	Number of Samples	Concentration-weighted fraction of total (percent)				
			Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Upstream of Otsego Dam	1993	11	22	0.0	8.5	63	6.1
Upstream of Trowbridge Dam	1993	11	16	0.0	9.8	63	11
	1999	11	0.0	4.1	29	58	8.5
	All Years	22	12	1.1	15	62	10
Lake Allegan	1993	11	6.5	39	0.0	53	1.7
	1997	11	0.0	3.3	28	62	7.1
	1999	10	0.0	15	25	52	8.5
	All Years	32	5.0	32	6.1	54	3.1
Swan Creek Marsh	1993	11	9.8	23	5.1	62	0.4
Near New Richmond	1993	11	3.9	0.0	27	63	6.0
	1997	11	0.0	3.0	31	59	6.8
	1999	11	0.0	0.0	18	71	11
	All Years	33	0.9	1.3	26	64	7.9
Near Saugatuck	1999	11	0.0	0.0	35	56	9.4
SMALLMOUTH BASS & CARP							
Near Battle Creek	1993	22	0.0	0.0	0.0	71	29
	1997	21	0.0	0.0	0.0	84	16
	All Years	43	0.0	0.0	0.0	76	24
Morrow Lake	1993	22	0.0	0.0	0.0	70	30
	1997	21	0.0	0.0	0.0	67	33
	1999	22	0.0	0.0	1.0	88	11
	All Years	65	0.0	0.0	0.4	76	24
Upstream of Portage Creek	1993	22	0.0	0.0	0.0	83	17
Near Mosel Avenue in Kalamazoo	1993	22	18	3.8	0.0	72	6.7
	1999	22	0.0	6.6	29	57	7.8
	All Years	44	8.9	5.2	15	64	7.2
Upstream of Plainwell Dam	1993	22	4.4	14	36	42	3.5
	1997	22	0.0	1.1	55	39	4.2
	1999	22	0.0	0.1	58	36	5.5
	All Years	66	1.4	4.6	50	39	4.5
Plainwell Dam to Otsego City Dam	1993	22	5.8	2.3	14	64	14
	1999	11	0.0	3.0	34	55	7.4
	All Years	33	4.7	2.4	18	63	13
Upstream of Otsego Dam	1993	22	13	15	13	55	4.0

(See notes on page 5)

Table 1

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish by Aquatic Biota Sampling Area

Species/ Location	Year	Number of Samples	Concentration-weighted fraction of total (percent)				
			Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Upstream of Trowbridge Dam	1993	22	7.4	0.0	26	57	10
	1999	22	0.0	15	30	48	6.1
	All Years	44	4.9	5.3	27	54	8.8
Lake Allegan	1993	22	4.2	25	15	52	3.2
	1997	22	0.0	1.4	24	63	12
	1999	21	0.0	5.2	28	56	11
	All Years	65	2.5	17	20	55	6.4
Swan Creek Marsh	1993	22	2.0	4.5	22	62	9.7
Near New Richmond	1993	22	0.4	0.0	6.3	86	7.4
	1997	23	0.0	4.9	16	68	11
	1999	22	0.0	0.0	31	60	8.9
	All Years	67	0.1	1.9	17	72	9.0
Portage Creek (Bryant Mill Pond)	1993	11	0.0	0.0	87	6.0	7.0
Near Saugatuck	1999	22	0.0	3.1	34	56	6.7
WALLEYE							
Plainwell Dam to Otsego City Dam	1999	1	0.0	0.0	53	40	6.8
Upstream of Trowbridge Dam	1999	1	0.0	0.0	36	55	8.7
Lake Allegan	1999	11	0.0	11	33	52	4.2
Near New Richmond	1999	11	0.0	0.0	43	49	7.8
Near Saugatuck	1999	8	0.0	0.0	42	55	3.3
Discrete Whole-body Samples							
SUCKERS							
Near Battle Creek	1993	10	0.0	0.0	0.0	72	28
Morrow Lake	1993	11	0.0	0.0	0.0	86	14
Upstream of Portage Creek	1993	11	0.0	0.0	0.0	91	8.7
Near Mosel Avenue in Kalamazoo	1993	11	4.7	21	8.0	60	6.8
Upstream of Plainwell Dam	1993	11	2.5	2.9	44	45	5.3
Plainwell Dam to Otsego City Dam	1993	11	14	6.5	31	46	1.9
Upstream of Otsego Dam	1993	11	16	8.7	26	48	1.9
Upstream of Trowbridge Dam	1993	11	3.4	0.0	3.9	81	12
Lake Allegan	1993	11	3.9	19	12	57	7.5
Swan Creek Marsh	1993	11	0.0	7.3	28	55	8.9
Near New Richmond	1993	11	0.0	9.9	45	45	0.0
Portage Creek (Bryant Mill Pond)	1993	11	2.0	19	65	9.7	4.5
	1998	11	0.0	68	32	0.0	0.0
	1999	11	0.0	0.0	73	14	14
	All Years	33	0.7	47	46	4.0	2.2

(See notes on page 5)

Table 1

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish by Aquatic Biota Sampling Area

Species/ Location	Year	Number of Samples	Concentration-weighted fraction of total (percent)				
			Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Composite Whole-body Samples							
CAGED FISH							
Portage Creek (Bryant Mill Pond)	1998	10	0.0	96	2.8	1.3	0.4
	1999	9	0.0	21	65	14	0.0
	All Years	19	0.0	79	17	4.2	0.3
SMALLMOUTH BASS							
Near Battle Creek	1997	5	0.0	0.0	0.0	81	19
Morrow Lake	1997	5	0.0	0.0	0.0	87	13
	1999	5	0.0	0.0	0.0	98	2.4
	All Years	10	0.0	0.0	0.0	94	6.2
Upstream of Plainwell Dam	1997	5	0.0	0.0	52	41	7.0
	1999	5	0.0	0.0	57	40	2.4
	All Years	10	0.0	0.0	54	40	5.2
Upstream of Trowbridge Dam	1999	5	0.0	0.0	33	55	12
Lake Allegan	1997	6	0.0	0.0	54	37	9.0
	1999	4	0.0	13	46	41	0.0
	All Years	10	0.0	4.4	51	39	6.0
Near New Richmond	1997	5	0.0	0.0	35	59	6.1
	1999	5	0.0	25	30	44	1.2
	All Years	10	0.0	13	32	51	3.6
Near Saugatuck	1999	5	0.0	0.0	55	42	2.3

Notes:

1. Aroclor-1221 and Aroclor-1232 were not quantified in any sample.
2. Suckers include a combination of white suckers, spotted suckers, golden redhorse suckers, and northern hogsuckers.
3. Detailed PCB data are presented in the draft *RI/FS Report* (BBL, 2000), draft *Supplement to the RI/FS Report* (BBL, 2000), and/or *Update for Decision Makers* (BBL, 2001).

Table 2

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish Collected
Upstream of Morrow Dam

Species/ Year	Number of Samples	Concentration-weighted fraction of total (percent)				
		Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Discrete Fillet Samples						
CARP						
1993	22	0.0	0.0	0.0	66	34
1997	21	0.0	0.0	0.0	66	34
1999	11	0.0	0.0	0.0	89	11
All Years	54	0.0	0.0	0.0	73	27
SMALLMOUTH BASS						
1993	22	0.0	0.0	0.0	76	24
1997	21	0.0	0.0	0.0	85	15
1999	11	0.0	0.0	3.2	88	8.9
All Years	54	0.0	0.0	0.9	81	18
SMALLMOUTH BASS & CARP						
1993	44	0.0	0.0	0.0	70	30
1997	42	0.0	0.0	0.0	72	28
1999	22	0.0	0.0	1.0	88	11
All Years	108	0.0	0.0	0.3	76	24
Discrete Whole-body Samples						
SUCKERS						
1993	21	0.0	0.0	0.0	84	16

Notes:

1. Aroclor-1221 and Aroclor-1232 were not quantified in any sample.
2. Suckers include a combination of white suckers, spotted suckers, golden redhorse suckers, and northern hogsuckers.
3. Detailed PCB data are presented in the draft *RI/FS Report* (BBL, 2000), draft *Supplement to the RI/FS Report* (BBL, 2000), and/or *Update for Decision Makers* (BBL, 2001).

Table 3

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish Collected in Portage Creek (Bryant Mill Pond)

Species/ Year	Number of Samples	Concentration-weighted fraction of total (percent)				
		Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Discrete Fillet Samples						
CARP						
1993	11	0.0	0.0	87	6.0	7.0
Discrete Whole-body Samples						
SUCKERS						
1993	11	2.0	19	65	9.7	4.5
1998	11	0.0	68	32	0.0	0.0
1999	11	0.0	0.0	73	14	14
All Years	33	0.7	47	46	4.0	2.2

Notes:

1. Aroclor-1221 and Aroclor-1232 were not quantified in any sample.
2. Suckers include a combination of white suckers, spotted suckers, golden redhorse suckers, and northern hogsuckers.
3. Detailed PCB data are presented in the draft *RI/FS Report* (BBL, 2000), draft *Supplement to the RI/FS Report* (BBL, 2000), and/or *Update for Decision Makers* (BBL, 2001).

Table 4

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish Collected between Morrow Dam and Lake Michigan

Species/ Year	Number of Samples	Concentration-weighted fraction of total (percent)				
		Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Discrete Fillet Samples						
CARP						
1993	99	4.1	4.7	19	63	8.8
1997	34	0.0	2.8	36	53	7.7
1999	66	0.0	4.0	42	47	6.8
All Years	199	2.1	4.2	29	57	8.0
SMALLMOUTH BASS						
1993	99	12	13	6	62	6.8
1997	33	0.0	3.3	28	61	7.7
1999	76	0.0	3.5	25	62	9.3
All Years	208	7.8	10	13	62	7.4
SMALLMOUTH BASS & CARP						
1993	198	5.9	6.8	16	63	8.3
1997	67	0.0	2.8	35	54	7.7
1999	142	0.0	4.0	40	49	7.1
All Years	407	3.3	5.4	26	58	7.8
Discrete Whole-body Samples						
SUCKERS						
1993	99	6.9	9.1	25	55	4.8

Notes:

1. Aroclor-1221 and Aroclor-1232 were not quantified in any sample.
2. Suckers include a combination of white suckers, spotted suckers, golden redhorse suckers, and northern hogsuckers.
3. Detailed PCB data are presented in the draft *RI/FS Report* (BBL, 2000), draft *Supplement to the RI/FS Report* (BBL, 2000), and/or *Update for Decision Makers* (BBL, 2001).

Table 5

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish Collected between Morrow Dam and Lake Allegan Dam

Species/ Year	Number of Samples	Concentration-weighted fraction of total (percent)				
		Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Discrete Fillet Samples						
CARP						
1993	77	5.8	6.7	20	60	8.1
1997	22	0.0	0.8	54	40	4.9
1999	44	0.0	4.7	44	44	6.5
All Years	143	3.0	5.3	33	52	7.2
SMALLMOUTH BASS						
1993	77	12	12	5.7	62	7.9
1997	22	0.0	3.7	25	63	8.6
1999	54	0.0	4.6	26	61	8.9
All Years	153	8.8	10	11	62	8.2
SMALLMOUTH BASS & CARP						
1993	154	7.6	8.2	16	60	8.1
1997	44	0.0	1.2	50	43	5.4
1999	98	0.0	4.7	42	47	6.8
All Years	296	4.3	6.3	28	54	7.4
Discrete Whole-body Samples						
SUCKERS						
1993	77	7.8	9.0	23	56	5.2

Notes:

1. Aroclor-1221 and Aroclor-1232 were not quantified in any sample.
2. Suckers include a combination of white suckers, spotted suckers, golden redhorse suckers, and northern hogsuckers.
3. Detailed PCB data are presented in the draft *RI/FS Report* (BBL, 2000), draft *Supplement to the RI/FS Report* (BBL, 2000), and/or *Update for Decision Makers* (BBL, 2001).

Table 6

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Summary of PCB Aroclor Results in Fish Collected between Lake Allegan Dam and Lake Michigan

Species/ Year	Number of Samples	Concentration-weighted fraction of total (percent)				
		Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Discrete Fillet Samples						
CARP						
1993	22	0.0	0.0	18	72	10
1997	12	0.0	5.3	13	70	11
1999	22	0.0	1.2	34	57	7.7
All Years	56	0.0	1.5	20	68	9.9
SMALLMOUTH BASS						
1993	22	8.5	18	9.9	62	1.7
1997	11	0.0	3.0	31	59	6.8
1999	22	0.0	0.0	23	66	10
All Years	55	4.5	10	18	62	4.9
SMALLMOUTH BASS & CARP						
1993	44	1.4	2.9	16	70	8.9
1997	23	0.0	4.9	16	68	11
1999	44	0.0	1.0	32	59	8.2
All Years	111	0.7	2.9	20	67	9.1
Discrete Whole-body Samples						
SUCKERS						
1993	22	0.0	9.2	41	48	2.2

Notes:

1. Aroclor-1221 and Aroclor-1232 were not quantified in any sample.
2. Suckers include a combination of white suckers, spotted suckers, golden redhorse suckers, and northern hogsuckers.
3. Detailed PCB data are presented in the draft *RI/FS Report* (BBL, 2000), draft *Supplement to the RI/FS Report* (BBL, 2000), and/or *Update for Decision Makers* (BBL, 2001).

Table 7

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

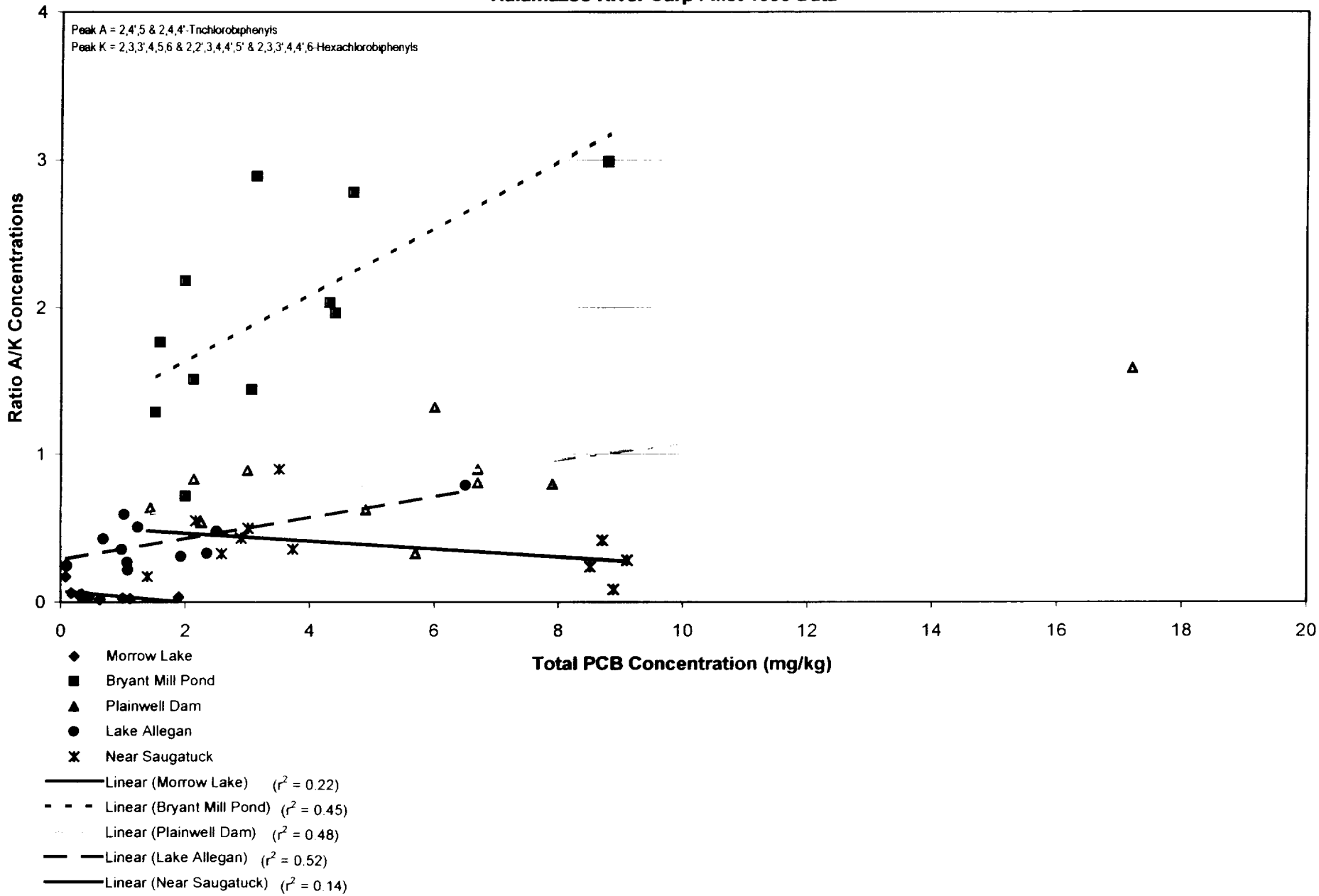
Summary of PCB Aroclor Results in Fish Collected within the Kalamazoo River (Battle Creek to Lake Michigan)

Species/ Year	Number of Samples	Concentration-weighted fraction of total (percent)				
		Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Discrete Fillet Samples						
CARP						
1993	121	4.0	4.6	19	63	9.2
1997	55	0.0	2.7	35	54	8.4
1999	77	0.0	4.0	41	48	6.8
All Years	253	2.1	4.1	29	57	8.3
SMALLMOUTH BASS						
1993	121	11.3	13	6	62	7.3
1997	54	0.0	3	26	63	8.1
1999	87	0.0	3	24	63	9.3
All Years	262	7.5	10	12	63	7.8
SMALLMOUTH BASS & CARP						
1993	242	5.8	7	16	63	8.7
1997	109	0.0	3	34	55	8.4
1999	164	0.0	4	39	50	7.2
All Years	515	3.2	5	25	58	8.2
Discrete Whole-body Samples						
SUCKERS						
1993	120	6.6	8.6	23	56	5.3

Notes:

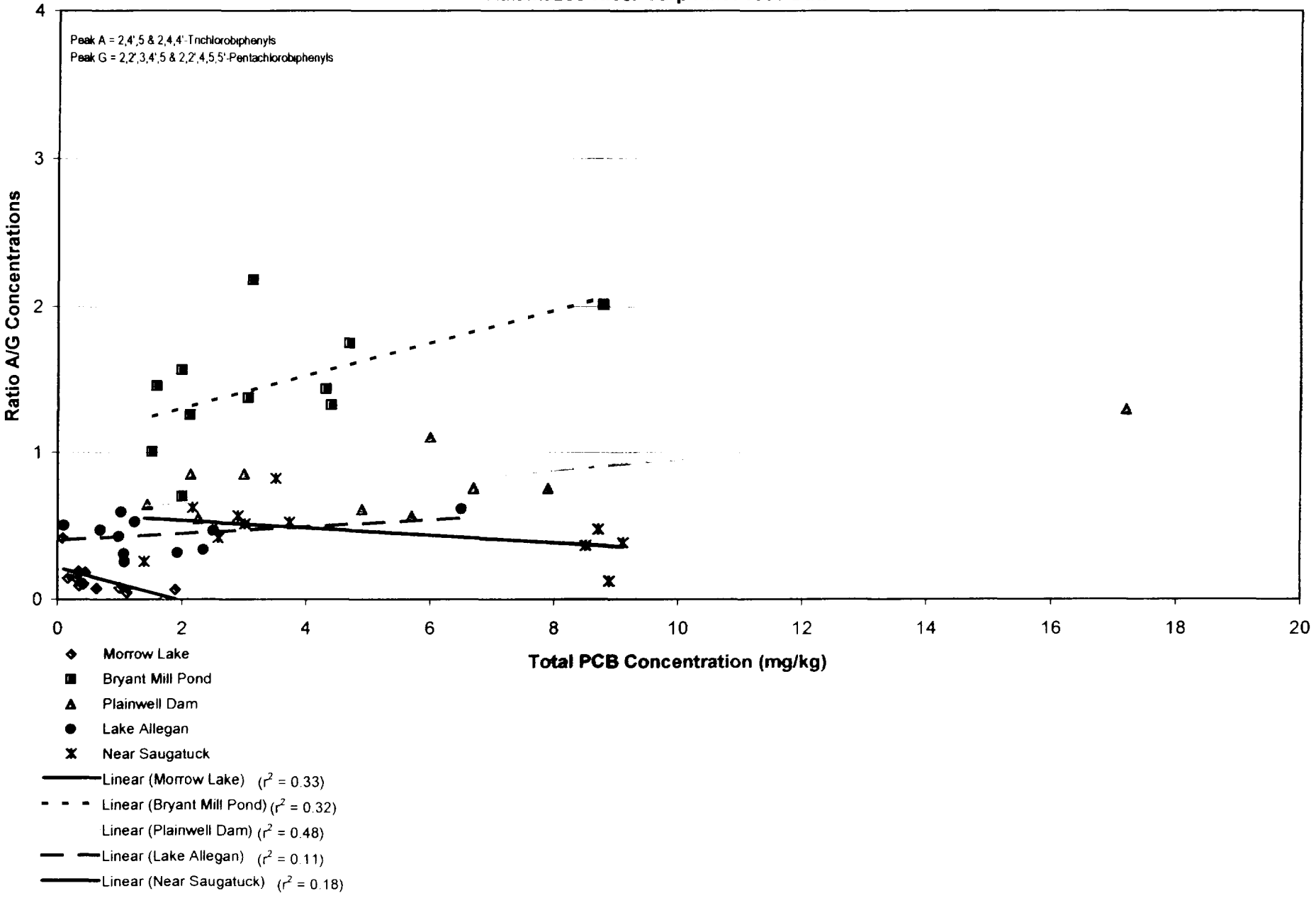
1. Aroclor-1221 and Aroclor-1232 were not quantified in any sample.
2. Suckers include a combination of white suckers, spotted suckers, golden redhorse suckers, and northern hogsuckers.
3. Detailed PCB data are presented in the draft *RI/FS Report* (BBL, 2000), draft *Supplement to the RI/FS Report* (BBL, 2000), and/or *Update for Decision Makers* (BBL, 2001).

Figure 1
PCB Chromatogram Peaks A/K PCB Concentration Ratio vs Total PCB Concentration
Kalamazoo River Carp Fillet 1993 Data



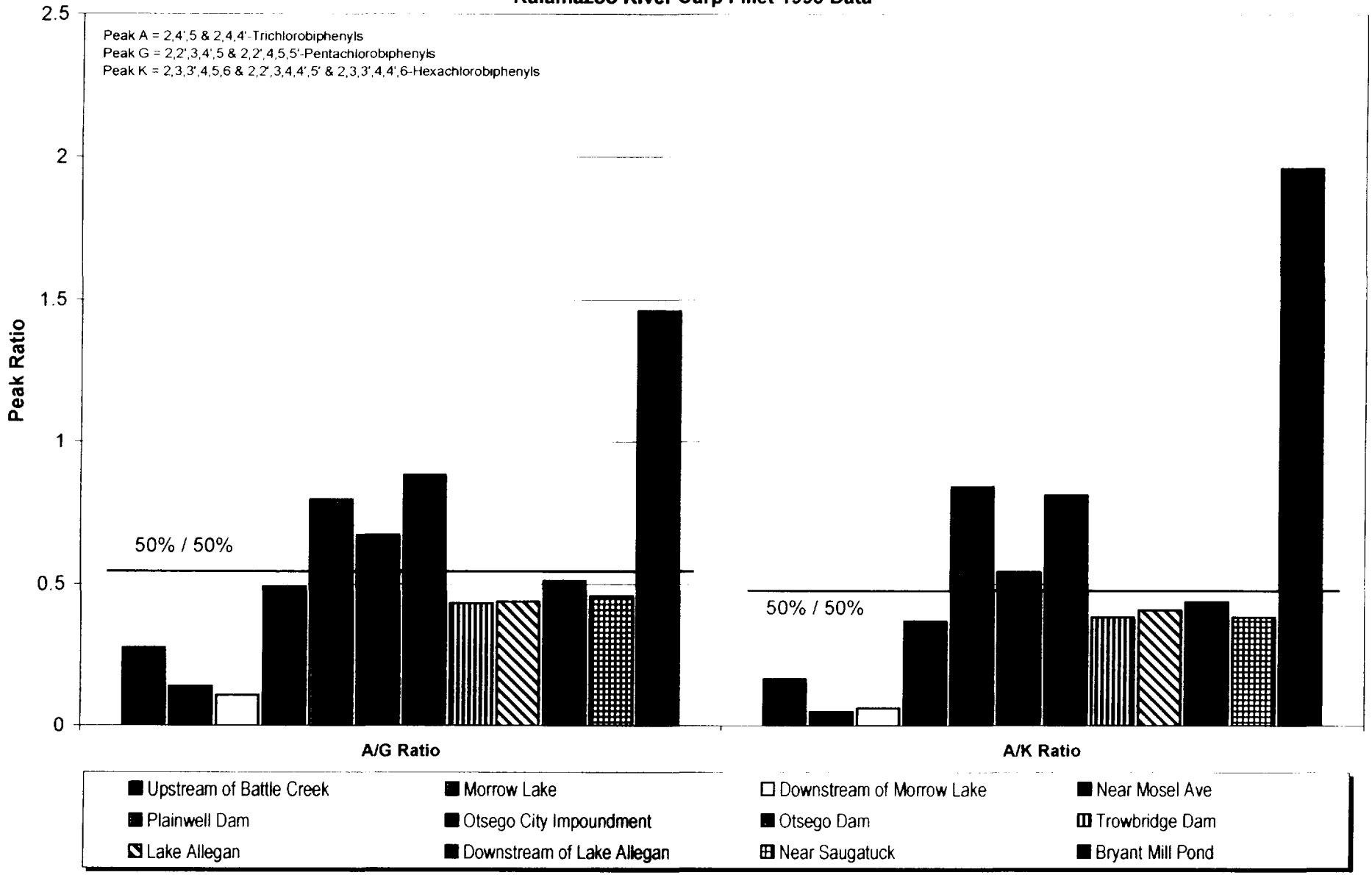
AKG Figures.xls_Figure 1_3/19/2003

Figure 2
PCB Chromatogram Peaks A/G PCB Concentration Ratio vs Total PCB Concentration
Kalamazoo River Carp Fillet 1993 Data



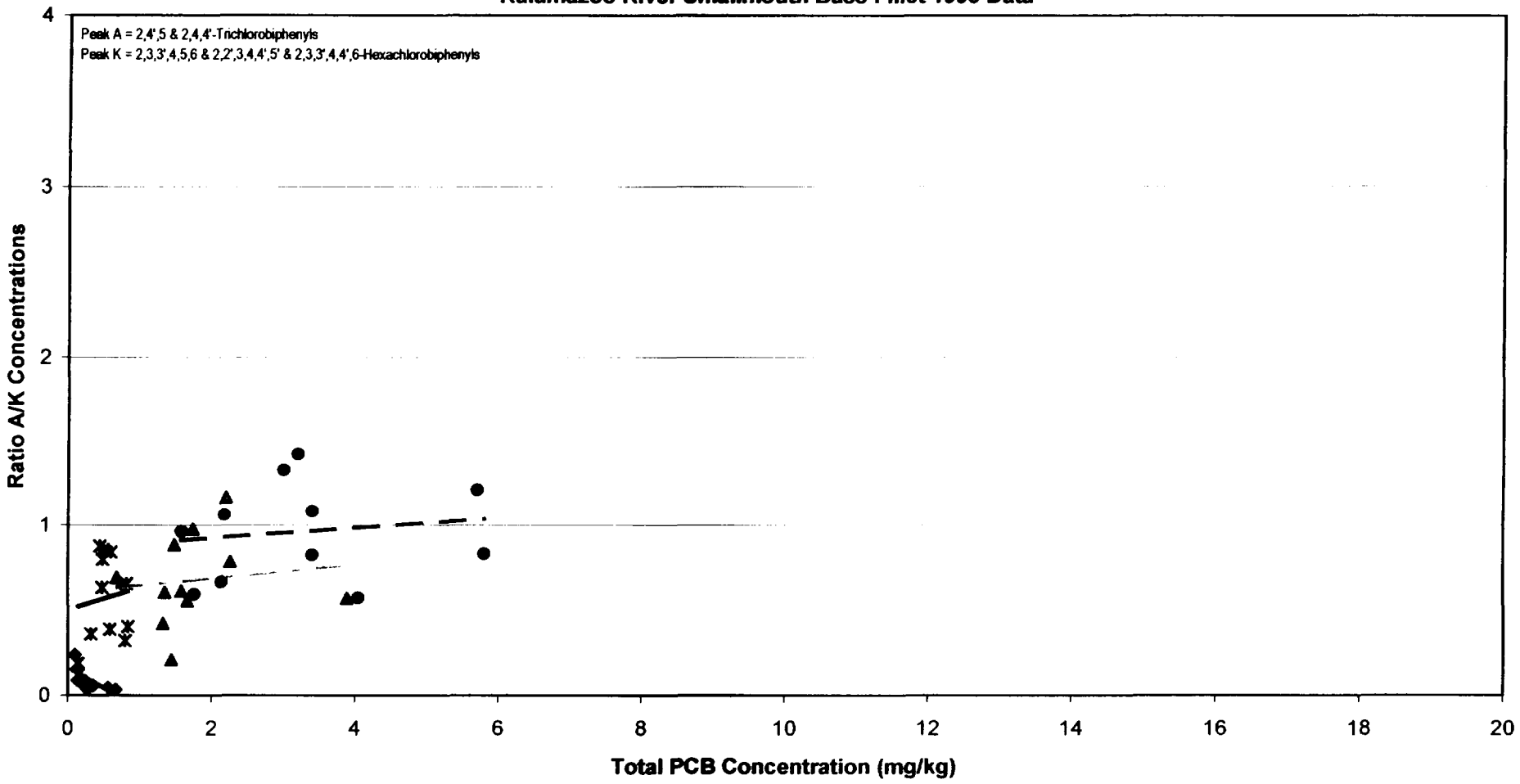
AKG Figures.xls_Figure 2_3/19/2003

Figure 3
PCB Chromatogram Peaks A/G and A/K PCB Concentration Ratio Averages
Kalamazoo River Carp Fillet 1993 Data



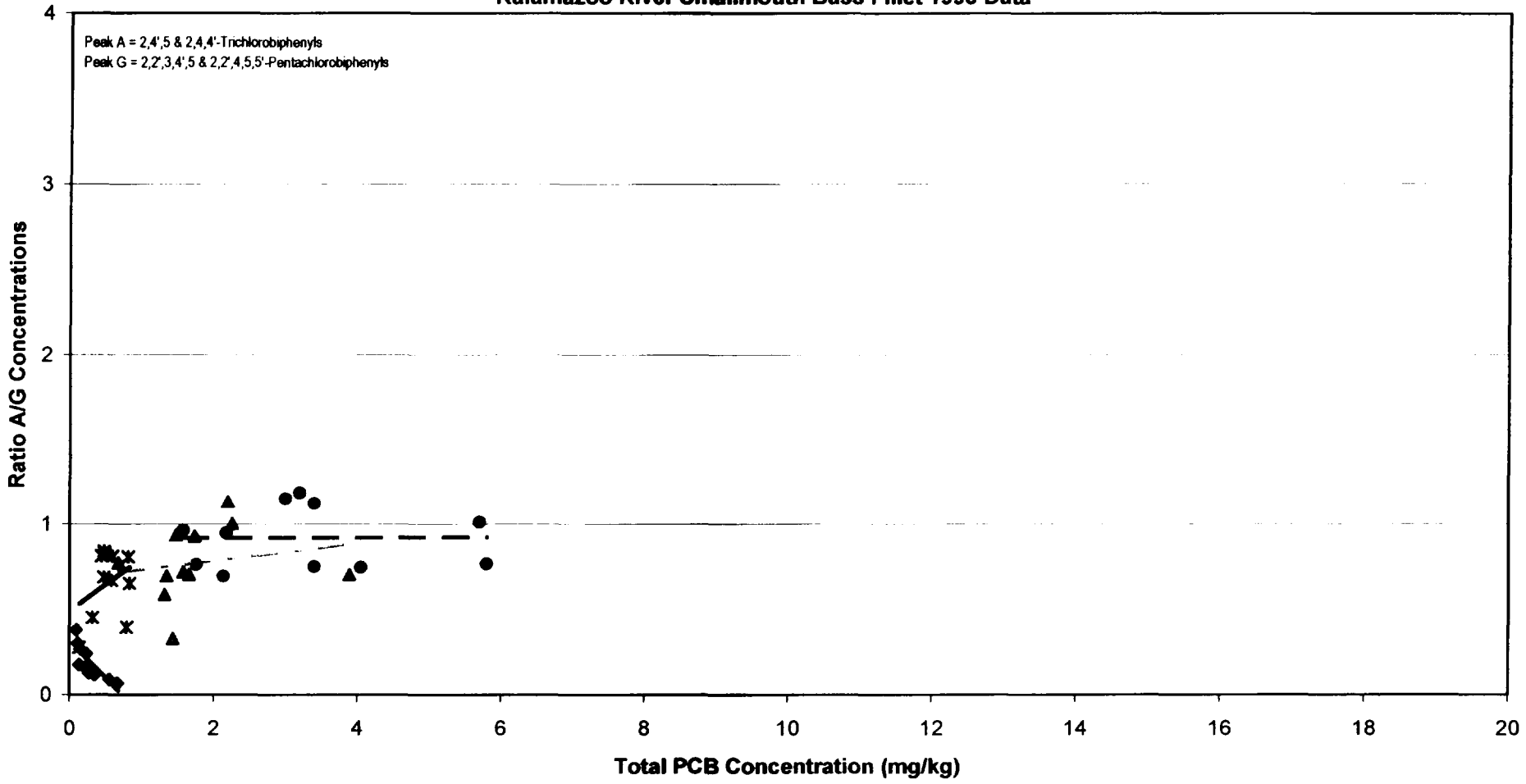
AKG Figures.xls_Figure 3_3/19/2003

Figure 4
PCB Chromatogram Peaks A/K PCB Concentration Ratio vs Total PCB Concentration
Kalamazoo River Smallmouth Bass Fillet 1993 Data



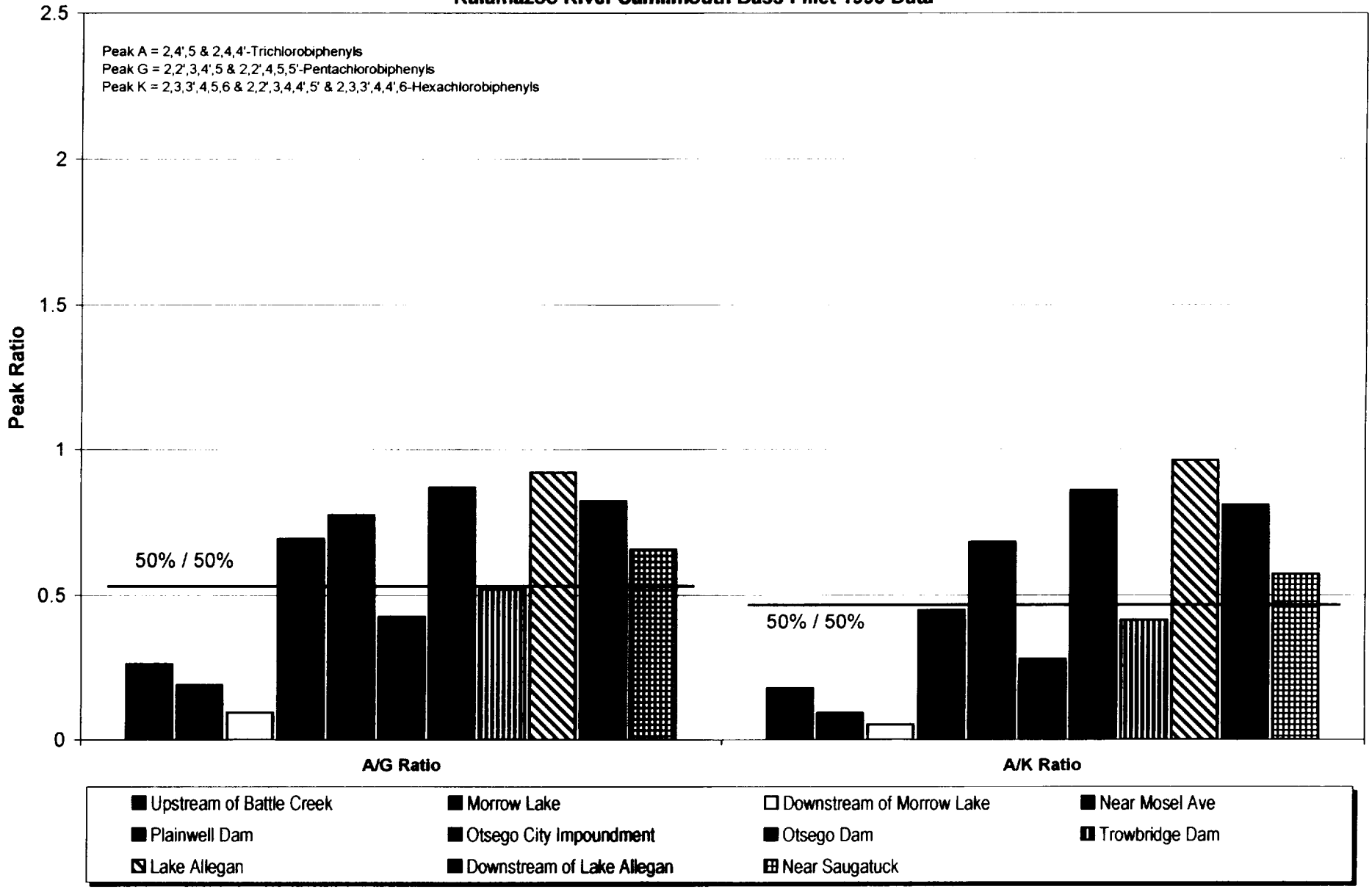
AKG Figures.xls_Figure 4_3/19/2003

Figure 5
PCB Chromatogram Peaks A/G PCB Concentration Ratio vs Total PCB Concentration
Kalamazoo River Smallmouth Bass Fillet 1993 Data



AKG Figures.xls_Figure 5_3/19/2003

Figure 6
PCB Chromatogram Peaks A/G and A/K PCB Concentration Ratio Averages
Kalamazoo River Samllmouth Bass Fillet 1993 Data



Section 3

Report Regarding the Environmental Response at the Allied Paper Inc./ Portage Creek/Kalamazoo River Superfund Site Fourth Addendum to April 7, 1997 Report

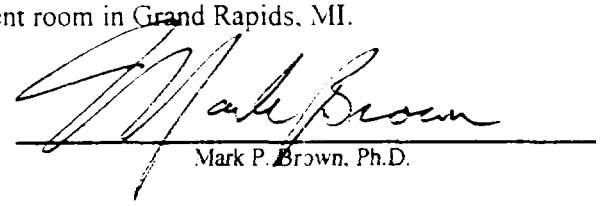
Allied Paper Inc./Portage
Creek/Kalamazoo River Superfund Site

April 27, 1998

Mark P. Brown, Ph.D.
Blasland, Bouck & Lee, Inc.

Report Regarding the Environmental Response at the Allied Paper Inc./ Portage Creek/Kalamazoo River Superfund Site Fourth Addendum to April 7, 1997 Report

This report is submitted in support of the litigation initiated by the members of the Kalamazoo River Study Group. This report summarizes my opinions and testimony which rely upon: my experience and education, the highlights of which were summarized in Section 1 of the April 7, 1997 report; the information generated during the Remedial Investigation of the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site; the exhibits described in and provided with the report and the documents contained in the document room in Grand Rapids, MI.



Mark P. Brown, Ph.D.

Allied Paper Inc./Portage Creek/Kalamazoo River Superfund Site

April 27, 1998

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

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Syracuse, New York, 13214-0066
(315) 446-9120

This report supplements my April 7, 1997 expert report (Brown, 1997) by presenting additional information regarding the presence of sources of polychlorinated biphenyls (PCB) to the Kalamazoo River. In my opinion, the facts, observations, and conclusions in this document are true to a reasonable degree of scientific certainty.

I have evaluated sediment and fish PCB data for the Kalamazoo River from the Ceresco Impoundment through New Richmond, a distance of approximately 65 miles, to assess the evidence of PCB sources unrelated to the recycling of waste paper. Over the past three months I have reviewed the analytical data for the sediment samples collected during 1993 and analyzed and reported in late 1997 and early 1998, and the data for the fish collected in autumn 1997 and autumn 1993 as part of the remedial investigation (RI) of the Kalamazoo River. Chromatographic data and the reported best-fit Aroclor-equivalent concentrations were evaluated for evidence of PCB sources that cannot be reasonably explained by releases originating from the recycling of waste paper.

The sediment data reviewed include the results of 1,403 PCB analyses from sediment cores collected at 405 locations. The sediment cores were segmented for PCB analysis into 0-2 inch, 2-12 inch, and successive 12-inch layers for PCB analysis. Of the 405 0-2 inch sediment samples, 24 percent had PCB results reported as not detected. The median PCB concentration in the 0-2 inch sections was 0.20 milligrams per kilogram (mg/kg); 95 percent of the PCB results for the 0-2 inch sections were less than 5.9 mg/kg. In the 2-12 inch sections 35 percent of the results were reported as not detected. The median concentration was 0.13 mg/kg and 95 percent of the results were less than 20 mg/kg. The great majority of sample locations and the great majority of not detected PCB results were downstream of KRSG members.

The chromatographic data reviewed are the graphical plots known as chromatograms which are produced by gas chromatographs for quantitative analysis of PCB. Aroclor-equivalent concentration data, the amount of PCB quantified as various Aroclors in sediment and fish, has been produced by the project's analytical laboratory on a consistent basis using a statistical method. In this method, chromatograms of individual Aroclors and various combinations of Aroclors are statistically compared to the chromatogram of a fish or sediment sample. The comparison which produces the least error is then used to quantify the total PCB in the sample as the single Aroclor or combination of multiple Aroclors.

The spatial distribution of sediment chromatographic data and Aroclor data were reviewed for evidence of discontinuities or gradients that might suggest the influence of a particular historic or current point source of PCB as well as general influence of PCB sources that cannot be reasonably attributed to recycling of waste paper. Because fish play a central role in determining the need for responses and associated response costs at aquatic sites of PCB contamination in general and the Kalamazoo River site in particular, the spatial distribution of fish chromatographic data and Aroclor data were evaluated relative to the significance of PCB sources other than waste-paper recycling.

From this review I have concluded that although the origin and downstream influence of specific point sources of PCB is not apparent from the data, it is very clear that sources of PCB which cannot be reasonably attributed to waste-paper recycling contribute substantially to the levels of PCB seen in fish. Furthermore, as expected from the scientific information regarding the accumulation of PCB in fish, these other sources contribute proportionately more PCB to the total amount of PCB in fish than they contribute to the total PCB mass in sediment. Considering that PCB levels in fish are the primary reason that the Kalamazoo River is undergoing a remedial investigation/feasibility study (RI/FS) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), it is clear that sources of PCB other than waste-paper recycling have contributed substantially to the need for the RI/FS and its costs.

Evidence of spatial gradients in the composition of sediment PCB was assessed through three approaches. The first approach estimated the average chlorine content of the PCB mixtures in sediment samples. These estimates were obtained by summing the product of each of the Aroclor-equivalent concentrations in a sediment sample and the weight percent of chlorine in the particular Aroclor used for quantitation. The second approach evaluated the ratios of Aroclor 1242 to Aroclor 1254. These ratios were calculated for all samples which had more than 60 percent of the total PCB quantitated as Aroclor 1242 and/or Aroclor 1254. The third approach involved the estimation of PCB homolog distributions in each of the river reaches that were investigated as part of the RI/FS. The distribution of homologs was approximated by applying the known distribution of PCB homologs in Aroclors to the Aroclor equivalent concentrations of PCB in sediment.

Exhibit 1 is a figure which relates the average chlorine content of the PCB mixtures found in sediment samples to location along the Kalamazoo River from the Morrow Lake Dam through Lake Allegan. Displayed are the data for samples which contained PCB concentrations in excess of 1 mg/kg. Average percent chlorination in sediment samples as displayed in Exhibit 1 varies over a range from 42 percent to 60 percent. The data display only a very slight downward trend with increasing distance along the Kalamazoo River (the regression line through the data implies a decrease of 3.3 percent chlorine content over the distance reflected in Exhibit 1). There do not appear to be any abrupt discontinuities that can be identified within the overall scatter of the data that are plotted that would suggest a substantial influence of a single point source of PCB.

Similarly, the ratio of Aroclor 1242 to Aroclor 1254 in sediment samples, shown in Exhibit 2, generally increases with distance along the river; however, no abrupt shifts that might be evident of a substantial influence of a single point source are apparent within the scatter of data. The data in Exhibit 2 have been displayed to discriminate between surface and subsurface sediment samples and concentrations greater than 10 mg/kg PCB as well as concentrations less than 10 mg/kg PCB. Similar to Exhibit 1, there are no abrupt discontinuities along the length that would identify a substantial influence of any single point source of PCB. Looking solely at Exhibit 2, no conclusions can be drawn about the amounts of PCB contributed by particular types of industries.

Exhibit 3 presents summary information regarding the distribution of Aroclor 1242 to Aroclor 1254 ratios. In Exhibit 3 the data for Portage Creek are also summarized. Compared to the Kalamazoo River, ratios of Aroclor 1242 to Aroclor 1254 are higher in Portage Creek. The results for Portage Creek reflecting a much higher proportion of Aroclor 1242-like PCB are attributable to historic paper-making operations in the vicinity of and upstream of Alcott Street along Portage Creek. However, other types of PCB including Aroclor 1254 have been discharged to Portage Creek by sources other than paper-making operations as evident by two samples collected at the same location immediately upstream of Axtel Creek which contain 69 and 3.4 mg/kg of PCB quantified in total as Aroclor 1254.

For purposes of illustration of the presence of PCB sources other than waste-paper recycling, the distribution of Aroclor 1242 to Aroclor 1254 ratios for Portage Creek is reasonably assumed to be a model of the ratios of Aroclor 1242 to Aroclor 1254 that would exist in the Kalamazoo River if the only sources of PCB to the River had been those resulting from the recycling of waste paper. In reality, there is very clear evidence for historic Aroclor 1254 discharges in Portage Creek in the area of Axtel Creek. So, a sediment sample that reflects only the contribution from waste paper recycling might actually have a higher Aroclor 1242 to Aroclor 1254 ratio than that distribution provided in Exhibit 3 for Portage Creek. Notwithstanding the resulting tendency to over estimate the contribution of waste-paper recycling by using Portage Creek as a reference, it is apparent the ratios of Aroclor 1242 to Aroclor 1254 in Portage Creek sediment are much

higher than the ratios found in sediments along the Kalamazoo River. The principal reason for the difference in Aroclor 1242 to Aroclor 1254 ratios between Portage Creek and the Kalamazoo River is the contribution of higher molecular weight (i.e., Aroclor 1254-like) PCB from sources other than waste paper recycling.

The approximate homolog composition of sediment PCB mixtures along the Kalamazoo River and Portage Creek is illustrated in Exhibit 4. The homolog distributions presented in Exhibit 4 represent averages determined by concentration weighting. The data for the Kalamazoo River relative to Portage Creek display subtle increases in the relative amounts of pentachlorobiphenyls and hexachlorobiphenyls with increasing distance downstream of Portage Creek. Furthermore, the data shows substantially higher relative concentrations of pentachlorobiphenyls and hexachlorobiphenyls upstream of Portage Creek. As discussed below, these increases in pentachlorobiphenyls and hexachlorobiphenyls which cannot be accounted for by discharges from waste paper recycling are significant because these are the homologs that comprise the highest PCB levels in fish. This means there have been sources of heavier PCB mixtures such as Aroclor 1254, although the specific points of discharge cannot be discerned from this Exhibit alone.

For equal levels of exposure to Aroclor-derived PCB, fish accumulate more hexachlorobiphenyls than pentachlorobiphenyls, more pentachlorobiphenyls than tetrachlorobiphenyls, more tetrachlorobiphenyls than trichlorobiphenyls, and more trichlorobiphenyls than dichlorobiphenyls. Dichlorobiphenyls and monochlorobiphenyls are accumulated only to a very slight extent.

Exhibit 5-9 present fish chromatograms for white sucker collected from Bryant Mill Pond (Exhibit 5), Morrow Lake (Exhibit 6), and Trowbridge Impoundment (Exhibit 7) in addition to chromatograms for Aroclor 1242 (Exhibit 8) and Aroclor 1254 (Exhibit 9). White suckers were used to illustrate the PCB compositions because they represent the most standardized fish sample collected upstream of and within the NPL Site. The three specimens used to illustrate PCB composition represent the upper end of PCB concentrations measured in white sucker at these locations.

Peaks in the chromatograms have been labeled to facilitate comparison of the relative abundance of certain PCB compounds. For example, peak "G" in each of the chromatograms is the same peak. The labeling also includes the number of chlorine atoms associated with the predominant PCB compounds associated with each peak.

The similarity between Aroclor 1254 and Morrow Lake fish can be seen by examination and comparison of the prominent amplitude of peaks G through K in Exhibits 6 and 9. In contrast, peaks G through K have a relatively low abundance in both Aroclor 1242 (Exhibit 8) and Bryant Mill Pond fish (Exhibit 5). The Bryant Mill Pond fish chromatogram represents the distribution of PCB resulting from concentrated exposure to PCB originating from waste-paper recycling.

Turning attention to Exhibit 7, which presents a chromatogram for a fish within in the NPL site located downstream of both Morrow Lake and Bryant Mill Pond, one can see very clearly in peaks G through K the prominence of Aroclor 1254 as well as the presence of peaks also seen in Bryant Mill Pond fish and Aroclor 1242 (e.g., peaks A through G).

The exhibits illustrate the predominance of Aroclor 1242-derived PCB in Bryant Mill Pond fish while the predominance of Aroclor 1254-like PCB in Morrow Lake fish. In fish from Trowbridge Impoundment there is a very clear reflection of Aroclor 1254 PCB at levels relative to Aroclor 1242, that are much higher than those found in Bryant Mill Pond fish. The levels of Aroclor 1254-like PCB in the Trowbridge Impoundment fish cannot be explained by waste-paper recycling sources of PCB.

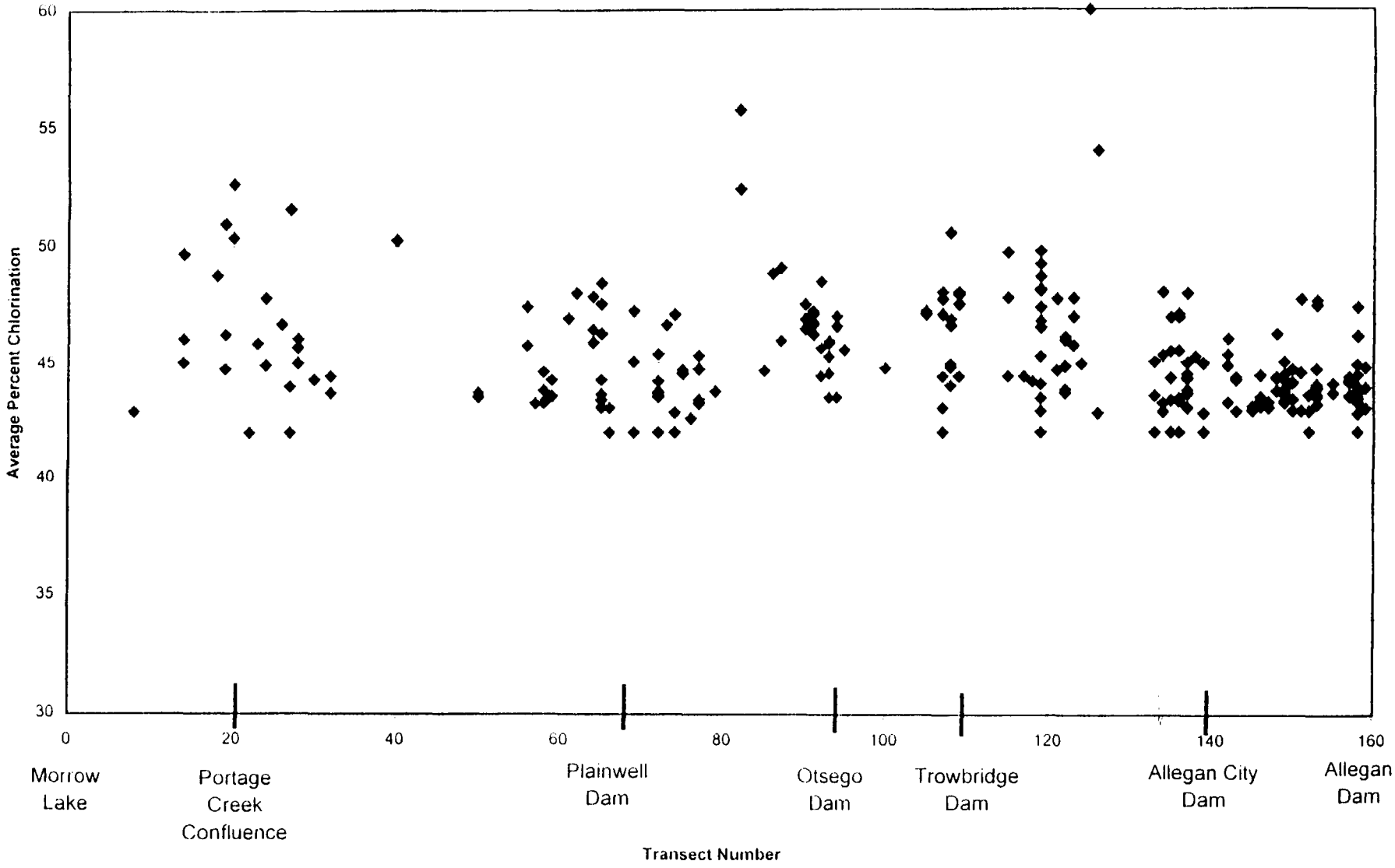
In addition to contributing substantially to PCB levels and composition in fish, these other-than-waste-paper PCB sources have contributed substantially to the RI/FS costs incurred by KRSG. Regulatory concern about PCB in aquatic environments, in general, and the Kalamazoo River in particular, stems from the potential human and ecological exposure that results from the accumulation of PCB in fish. A substantial portion of the PCB found in Kalamazoo River fish originated from sources other than waste-paper recycling. The particular sources of this other PCB are not reflected in any abrupt and substantial shift in sediment PCB composition along the length of the Kalamazoo River, although they clearly exist upstream of the NPL site and evidently exist within the NPL site as well.

All of my opinions herein are offered to a reasonable degree of scientific certainty and are intended to supplement the opinions I have previously offered.

EXHIBITS LIST

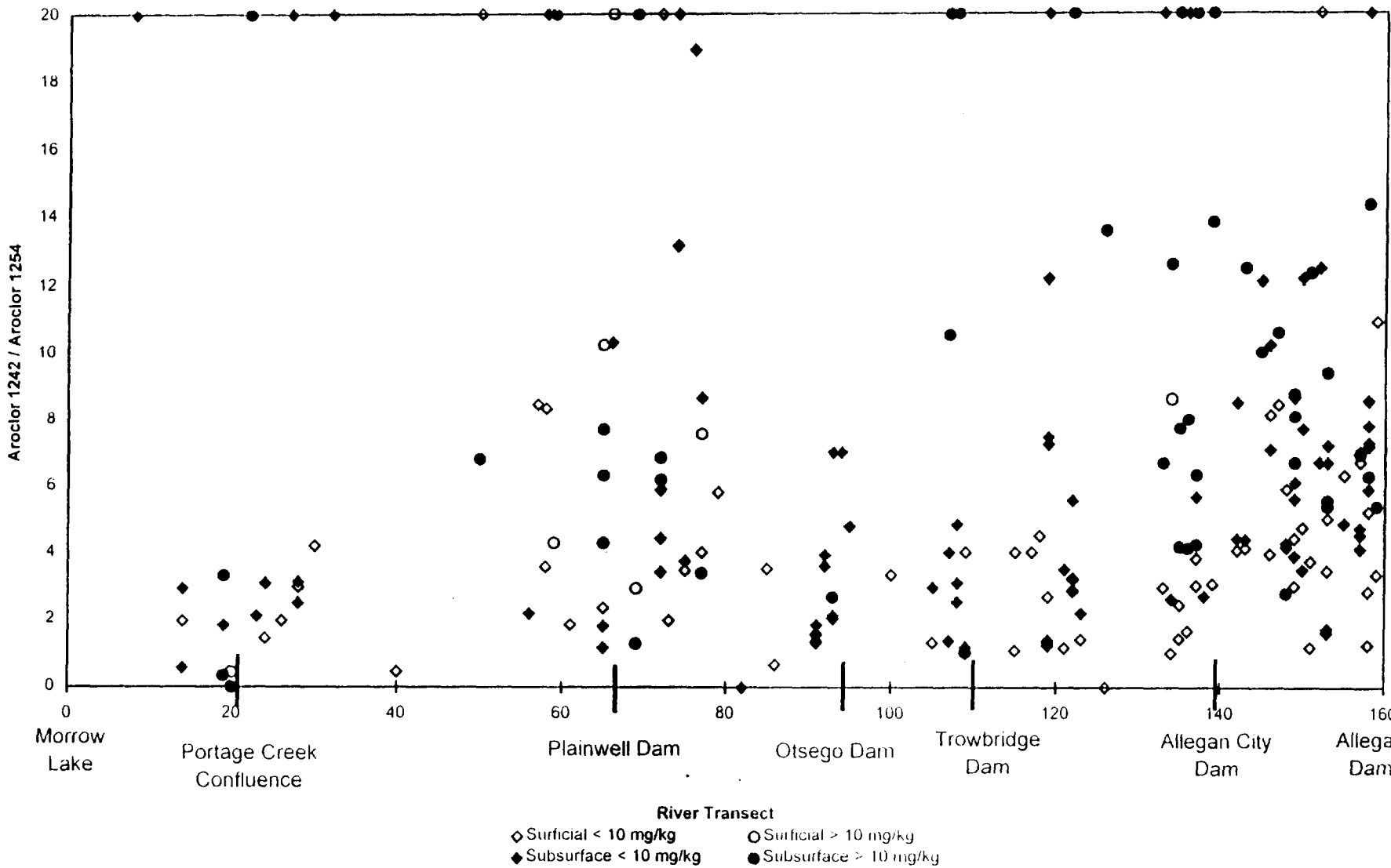
1. Downstream Trend in Average Percent Chlorination of Detected PCB.
2. Aroclor 1242 to Aroclor 1254 Ratio in Kalamazoo River Sediment.
3. Ratio of Aroclor 1242 to Aroclor 1254 by Reach in Kalamazoo River Sediment.
4. Kalamazoo River Sediment PCB Homolog Distribution.
5. Bryant Mill Pond White Sucker Chromatogram.
6. Morrow Lake White Sucker Chromatogram.
7. Trowbridge Dam White Sucker Chromatogram.
8. Aroclor 1242 Chromatogram.
9. Aroclor 1254 Chromatogram.

Exhibit 1
Downstream Trend in Average Percent Chlorination of Detected PCB
All Samples with PCB > 1 mg/kg (N=199)



ARODETCT XLS

Exhibit 2
Aroclor 1242 to Aroclor 1254 Ratio in Kalamazoo River Sediment
All Samples > 1 mg/kg Total PCB, by Transect



RATIO3.XLS

Note A ratio of 20 indicates those samples that are 95% or more Aroclor 1242 and 5% or less Aroclor 1254

Exhibit 3

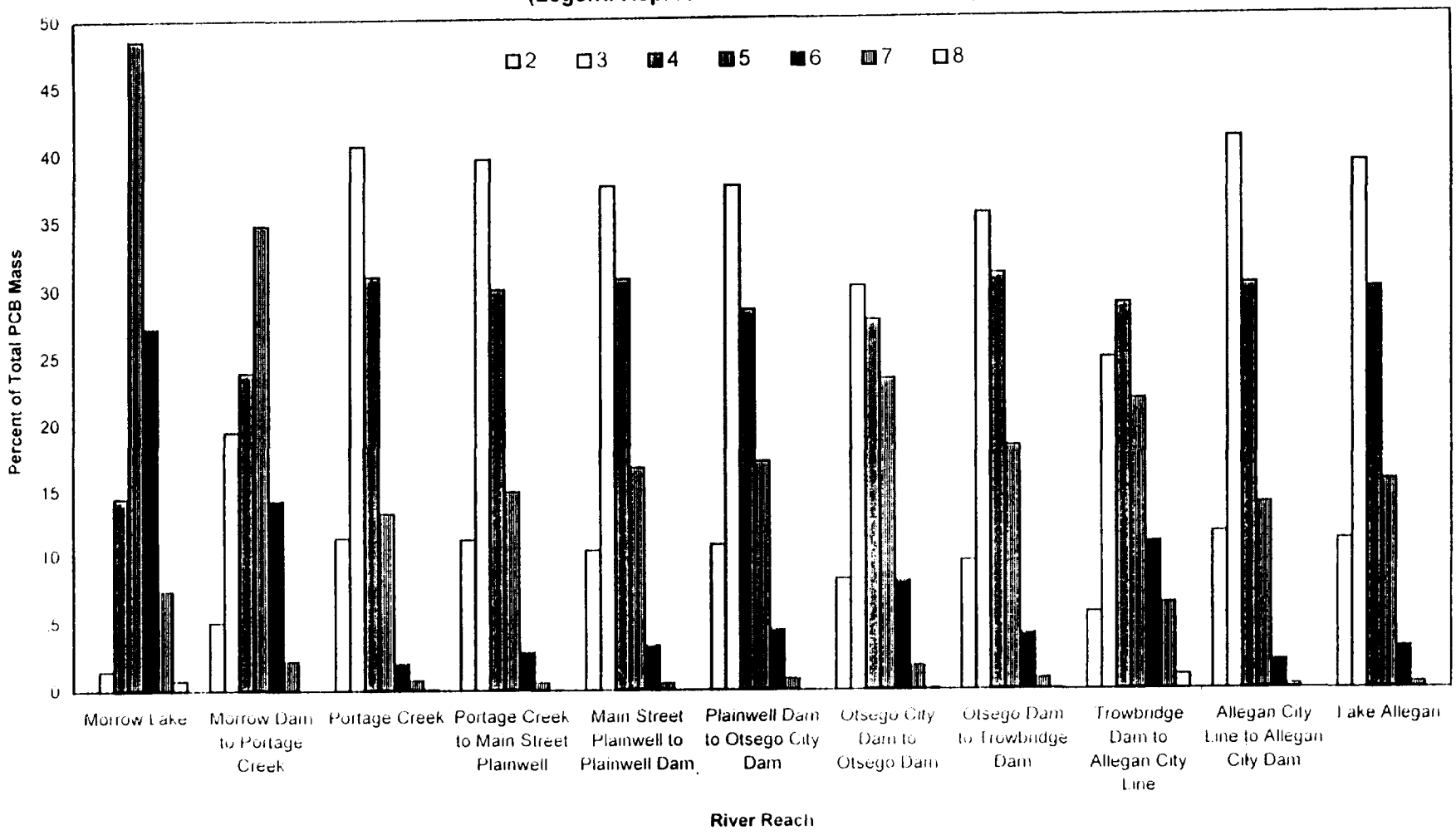
Ratio of Aroclor 1242 to Aroclor 1254 by Reach in Kalamazoo River Sediment

Kalamazoo River Sediment > 1 mg/kg								
Reach	**Description**	**N**	**Median**	**Range**	**5th Percentile**	**10th Percentile**	**90th Percentile**	**95th Percentile**
A1	Morrow Dam to Portage Creek Confluence	9	1.8	0 to >20	0	0	>20	>20
A2	Portage Creek Confluence to Main Street Plainwell	18	3.7	0.45 to >20	0.45	2.0	>20	>20
B	Main Street, Plainwell to Plainwell Dam	17	6.3	1.2 to >20	1.0	1.5	>20	>20
C	Plainwell Dam to Otsego City Dam	20	5.8	1.3 to >20	1.3	2.0	>20	>20
D	Otsego City Dam to Otsego Dam	15	2.0	0 to 7	0	0.33	7	7
E	Otsego Dam to Trowbridge Dam	17	3.3	1.0 to >20	0.9	1.0	>20	>20
F	Trowbridge Dam to Allegan City Line	22	2.9	1.1 to >20	1.1	1.2	>20	>20
G	Allegan City Line to Allegan Dam	33	6.7	0 to >20	1.2	1.5	>20	>20
H	Allegan City Dam to Allegan Dam	70	6.2	1.2 to >20	1.7	3.0	12.4	>20
P	Portage Creek	66	>20	0 to >20	1.5	4.4	>20	>20

Notes: Includes only those samples with PCB concentrations greater than 1.0 mg/kg and where 60% or more of the total PCB is the sum of Aroclors 1242 and 1254.

Percentiles were extrapolated where necessary and should be considered estimates only.

Exhibit 4
Kalamazoo River Sediment PCB Homolog Distribution
(Legend Represents Number of Chlorines)

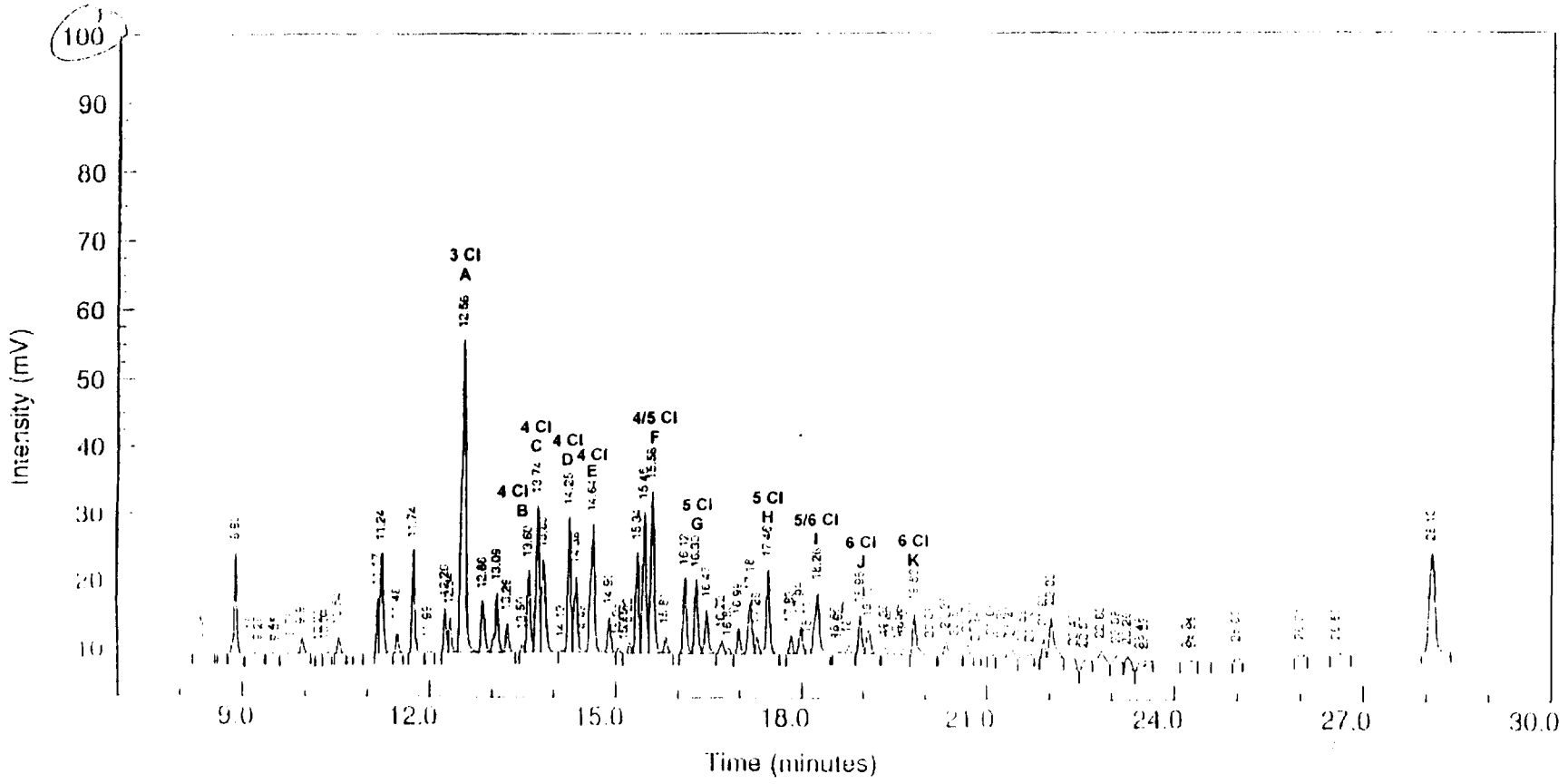


Note: Homologs with one and nine chlorines contributed less than one percent of the total PCB concentration and are not shown

EXHIBIT 5
Bryant Mill Pond White Sucker
PCB = 2.4 mg/kg

[8080] 6 25MAR941758,18,1.
Acquired on 26-MAR-1994 at 05:01
Reported by [AUTOP3] on 29-MAR-1994 at 11:11

aquatec Multichrom V2.0
Lab ID : 203919;1:5
Client ID : P40419



Instrument : HP2618-2
Channel Title : RTx-5
Amount : 1.000
1 uL Inj

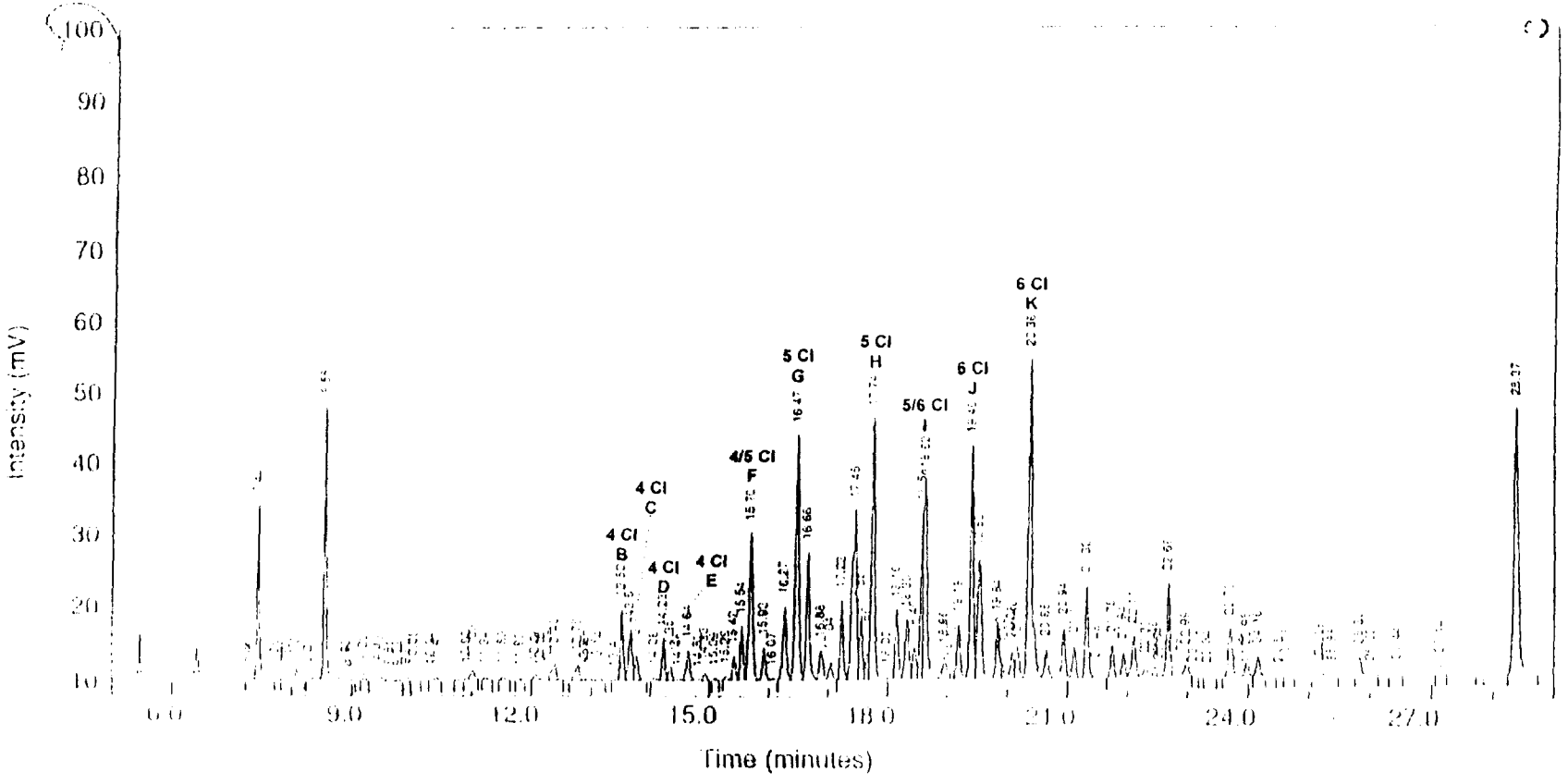
Method : 032394_3
Calibration : 032394_1
Run Sequence : 032594_1
Scale Factor :

XH 6

Morrow Lake White Sucker
PCB = 0.7 mg/kg

[8080] 4 19MAY941529,22,1.
Acquired on 20-MAY-1994 at 03:14
Reported by [AUTOP3] on 24-MAY-1994 at 11:51

aquatec Multichrom V2.0
Lab ID : 195017R1;;SCU
Client ID : K40018W

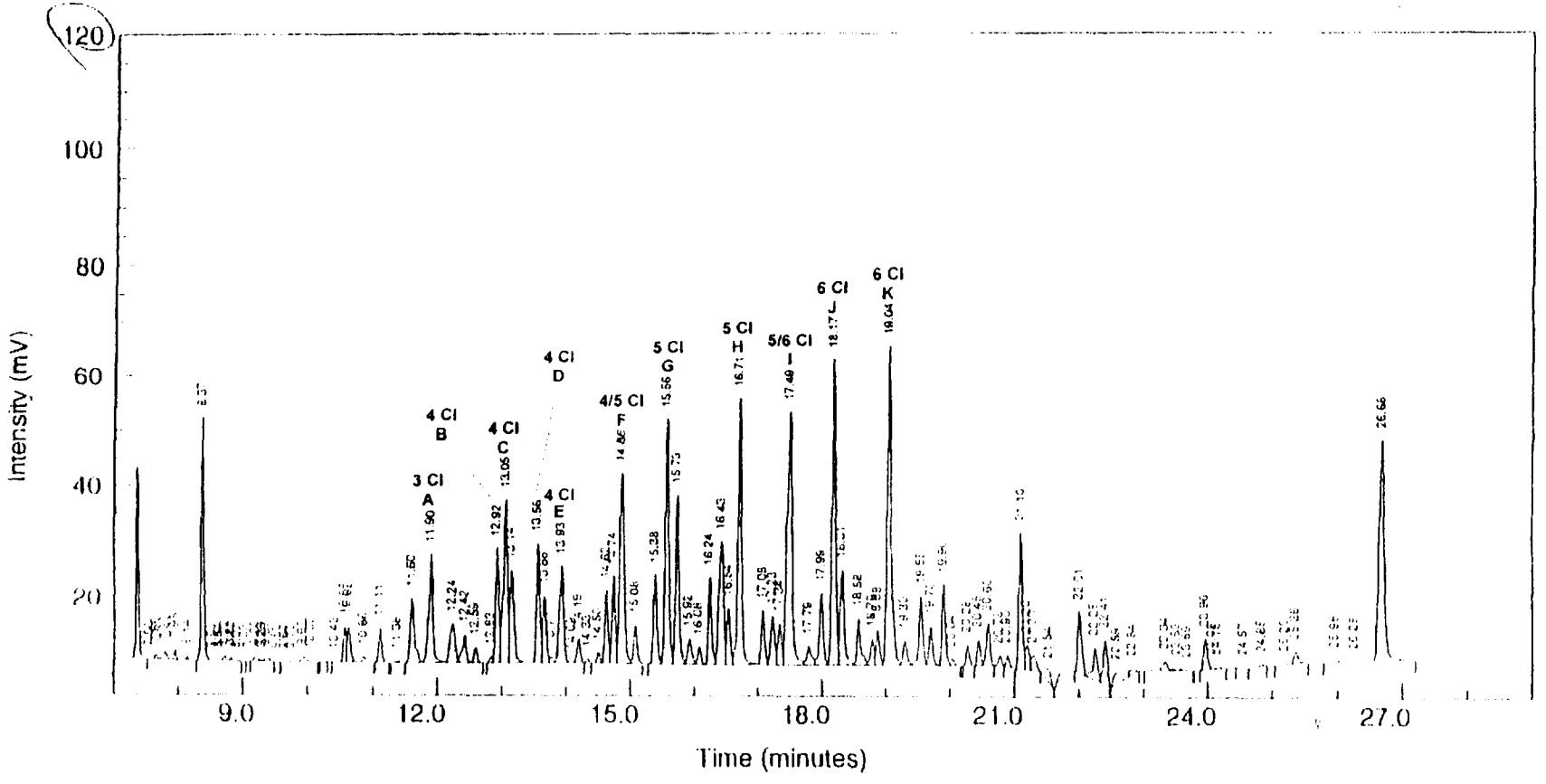


Instrument	: HP2087-2	Method	: 051894_3
Channel Title	: RTX-5	Calibration	: 051894_1
Amount	: 1.000	Run Sequence	: 051994_1
1 uL inj		Scale Factor	:

EXHIBIT 7
Trowbridge Dam White Sucker
PCB = 1.2 mg/kg

[8080] 6 11MAY941719,36,1.
Acquired on 12-MAY-1994 at 12:46
Reported by [AUTOP3] on 17-MAY-1994 at 18:27

aquatec Multichrom V2.0
Lab ID : 201586;1:2;SCU
Client ID : K40338W



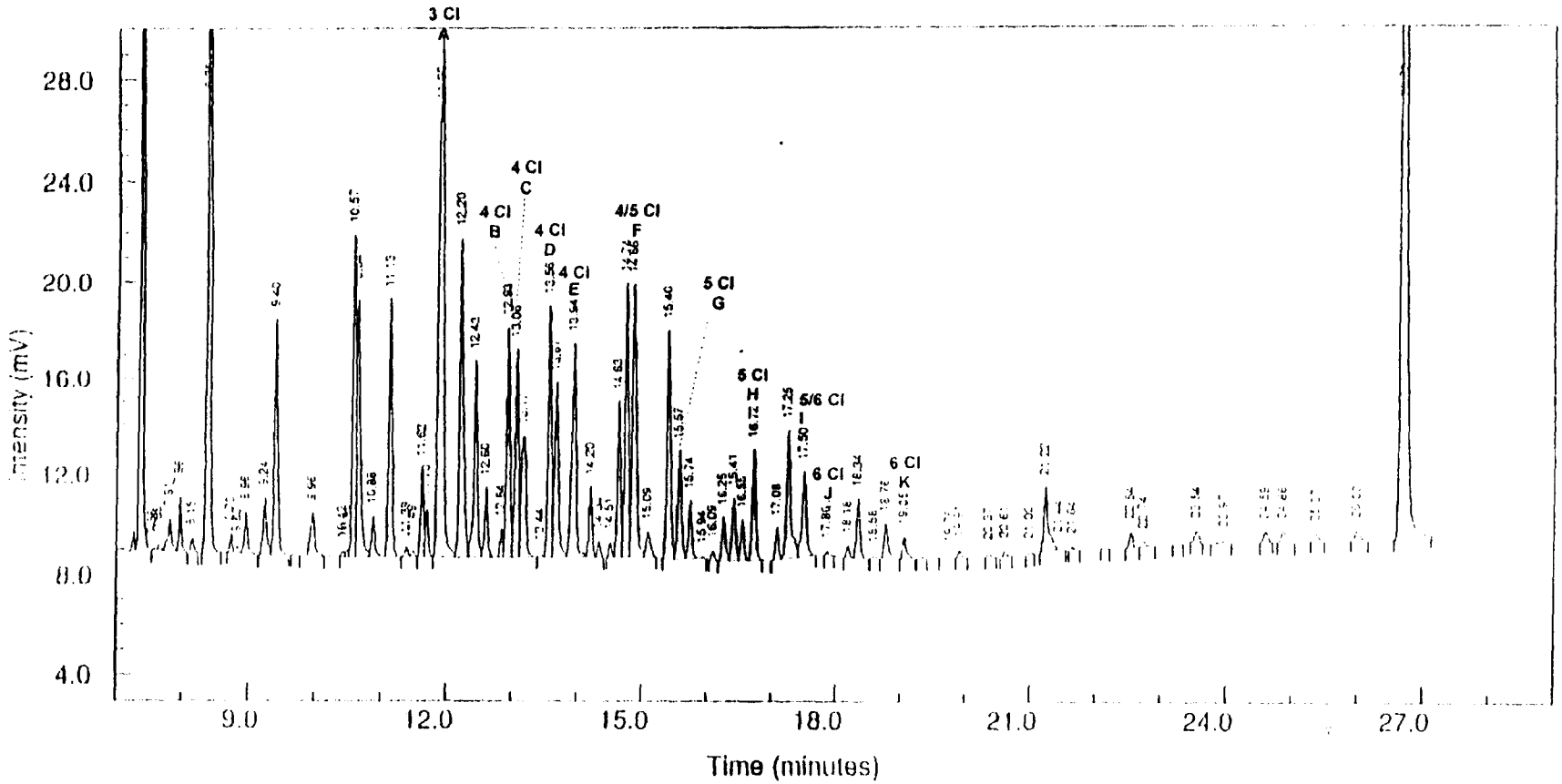
Instrument : HP2618-2
Channel Title : RTx-5
Amount : 1.000
1 uL inj

Method : 051094_3
Calibration : 051094_1
Run Sequence : 051194_1
Scale Factor :

EXHIBIT 8
Aroclor 1242
0.20 mg/kg

[8080] 6 10MAY941700,21,1.
Acquired on 11-MAY-1994 at 04:09
Reported by [AUTOP3] on 16-MAY-1994 at 20:54

aquatec Multichrom V2.0
Lab ID : AR1242 200ppb
Client ID :



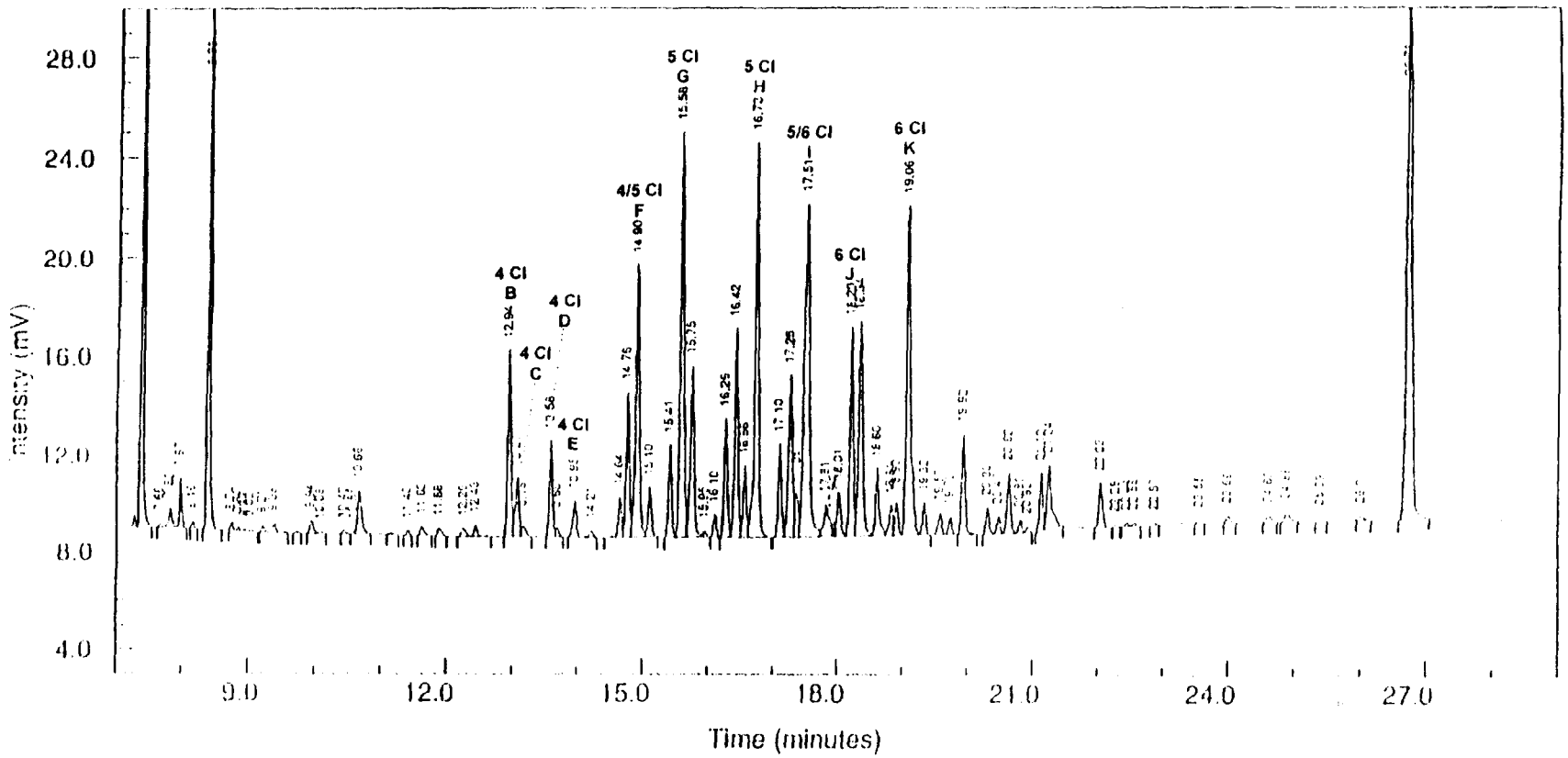
Instrument : HP2618-2
Channel Title : RTx-5
Amount : 1.000
1 uL inj

Method : 051094_2
Calibration : 051094_1
Run Sequence : 051094_1
Scale Factor :

EXHIBIT 9
Aroclor 1254
0.10 mg/kg

[8080] 6 10MAY941700,30,1.
Acquired on 11-MAY-1994 at 09:08
Reported by [AUTOP3] on 16-MAY-1994 at 21:03

aquatec Multichrom V2.0
Lab ID : AR1254 100ppb
Client ID :



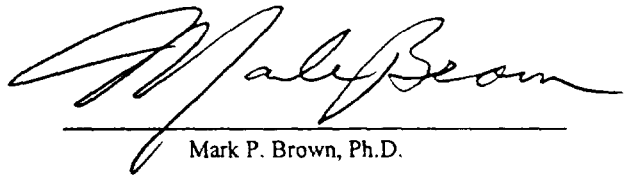
Instrument : HP2618-2
Channel Title : RTx-5
Amount : 1.000
1 uL inj

Method : 051094_2
Calibration : 051094_1
Run Sequence : 051094_1
Scale Factor :

Section 4

Report Regarding the Environmental Response at the Allied Paper, Inc./ Portage Creek/Kalamazoo River Superfund Site Sixth Addendum to April 7, 1997 Report

This report is submitted in support of the litigation initiated by the members of the Kalamazoo River Study Group. This report summarizes my opinions and testimony which rely upon: my experience and education, the highlights of which were summarized in Section 1 of the April 7, 1997 report; the information generated during the Remedial Investigation of the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site; the exhibits described in and provided with this and my other reports; and the documents produced in this case.



Mark P. Brown, Ph.D.

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

July 1, 1999

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

6723 Towpath Road, P.O. Box 66
Syracuse, New York, 13214-0066
(315) 446-9120

1. Introduction

This report supplements my April 7, 1997 expert report (Brown, 1997a), and my addenda dated September 15, 1997 (Brown, 1997b), December 18, 1997 (Brown, 1997c), April 21, 1998 (Brown, 1998a), April 27, 1998 (Brown, 1998b), and May 4, 1998 (Brown, 1998c), including all exhibits, attachments, and references to those reports. This report also supplements my testimony given at trial regarding the KRSG's liability claims against Eaton Corporation and Rockwell International (Brown, 1998d). This report presents additional information that further supports the conclusions, observations, and opinions stated in my earlier reports and testimony. All of my earlier reports, as well as my trial testimony, are incorporated herein by reference.

In my opinion, the facts, observations, and conclusions in this document are true to a reasonable degree of scientific certainty.

2. Background of Mark P. Brown, Ph.D.

The following supplements my background information contained in my earlier reports, which are incorporated herein by reference.

2.1 Present Job Title

I am currently a Senior Vice President of Blasland, Bouck & Lee, Inc. (BBL) at the company's headquarters in Syracuse, New York. I was promoted to this position in January 1998.

2.2 Compensation

The Kalamazoo River Study Group (KRSG) is compensating BBL at a rate of $210 per hour for my services in this matter.

3. Discussion

The need for a response under the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) for the Kalamazoo River is substantially related to the presence of polychlorinated biphenyls (PCBs) originating from releases of Aroclor 1254. Approximately half of the PCBs in Kalamazoo River fish are derived from Aroclor mixtures having levels of chlorine greater than that found in Aroclor 1242. Aroclor 1242 was the source of PCBs associated primarily with the paper industry's recycling of office paper. Aroclor 1254 is not associated with the paper industry's recycling of office paper, but is associated with industrial process oils.

The need for a CERCLA response at the Kalamazoo River Superfund Site is directly linked to the presence of PCB in fish. The greatest potential human exposure to PCB at the site is through fish consumption. Other potential exposure pathways such as direct contact with sediment, or incidental ingestion of water by recreationists would result in a very small fraction of the exposure to PCB that would result from the consumption of fish. The same is true for ecological risks associated with PCBs at the site: consumption of fish by fish-eating birds and mink lead to the greatest estimates of ecological risk at the site. At aquatic sites such as the Kalamazoo River, the most restrictive (i.e., lowest) cleanup objectives for PCBs in sediments are directly related to PCB levels in fish. The accumulation of PCB in fish is the pathway associated with the greatest human health and ecological risks, and other exposure pathways are of little if any significance. The levels of PCB in fish determine the need for a response at sites like the Kalamazoo River and at the Kalamazoo River in particular.

As I have testified previously (Brown, 1998d) and as presented in my April 27, 1998 Addendum to my April 7, 1997 report (Brown, 1998b), Aroclor 1254-derived PCB congeners are prominent in the composition of PCB found in Kalamazoo River fish. This was illustrated through the chromatograms for representative fish samples and Aroclor 1242 and Aroclor 1254 standards, set forth as Exhibits 5 through 9 to my April 27, 1998 report. These PCB congeners are prominent because they bioaccumulate in fish to a greater extent than Aroclor 1242-derived PCB congeners. The propensity for PCB to bioaccumulate in fish has been related to the chemical property referred to as the octanol-water partition coefficient (K_{ow}). In general, PCB congeners with greater octanol-water partition coefficients will accumulate to higher levels in aquatic biota than will PCB congeners with lesser octanol-water partition coefficients. Exhibit 1, which is attached to this report, is a figure taken from a research article by Parkerton et al. (1993) that relates the biota to sediment accumulation factor (BSAF) for PCBs to the logarithm of the octanol water partition coefficient (log K_{ow}). The BSAF is the ratio of PCB levels in an aquatic organism to the PCB level in surface sediment. To this figure, lines were added showing the approximate log K_{ow} for Aroclor 1242 and Aroclor 1254 (taken from ATSDR, 1998; also see Shiu and Mackay, 1986 for K_{ow}s for PCB congeners) and the corresponding BSAFs. As illustrated by Exhibit 1, for equal amounts of Aroclor 1242 and Aroclor 1254 in surface sediment, aquatic organisms would accumulate more than three times the amount of Aroclor 1254 PCB than Aroclor 1242 PCB.

To evaluate the approximate quantity of Aroclor 1254-derived PCB congeners in Kalamazoo River fish, BBL estimated PCB congener concentrations associated with certain chromatogram peaks from Kalamazoo River fish samples taken from different points along the River. The chromatogram peaks for which PCB congener concentrations were estimated are peaks A, G, and K which were previously identified in my April 27, 1998 expert report (Brown, 1998b), in my trial testimony (Brown, 1998d), and trial Exhibit PX-4013. Peak A congeners are prominent components of Aroclor 1242 and fish from Bryant Mill Pond. (Bryant Mill Pond fish are used to represent the composition of PCB that would be expected in the Kalamazoo River if the only source of PCB to the Kalamazoo River was the recycling of paper, because the predominant source of PCB to both the sediments an

fish of Bryant Mill Pond was the recycling of paper at the former Allied Paper, Inc. mills.) The peak A trichlorobiphenyls constitute 11 percent of Aroclor 1242 whereas they comprise only 0.5 percent of Aroclor 1254 (Schulz et al., 1989). On the other hand, the congeners associated with peak K are prominent in Aroclor 1254, comprising approximately 4 percent of this mixture while comprising only 0.5 percent of Aroclor 1242 (Schulz et al., 1989). Peak G has congeners that comprise 8.9 percent of Aroclor 1254 and 1.6 percent of Aroclor 1242. For the 1993 Kalamazoo River and Bryant Mill Pond fish samples, PCB congener concentrations were calculated for peaks A, G, and K using peak response factors developed from the response of Aroclor standards run on the RTX-5 column and the mass analyses of Aroclors reported for the SE-54 column by Schulz et al. (1989). Use of other analyses of Aroclors such as that by Frame (1997) would yield similar findings. Ratios of those congener concentrations were calculated and are summarized in Exhibits 2, 3, and 4, attached to this report.

Exhibits 2 and 3 present PCB concentration ratios for peaks A/G and peaks A/K, respectively. These two exhibits illustrate the variations in these ratios and the absence of any significant effect of total PCB concentration on the variability of these ratios. As also evident in Exhibits 2 and 3, the A/G and A/K ratios of Bryant Mill Pond fish and Morrow Lake fish plot respectively above and below the data for fish collected at Plainwell Dam, Lake Allegan, and Saugatuck on the Kalamazoo River. As qualitatively illustrated and explained in my April 27, 1998 expert report (Brown, 1998b), the composition of PCB in Kalamazoo River fish is a blending of the Aroclor 1242-like PCB mixture as characterized by Bryant Mill Pond fish and the Aroclor 1254-like mixture as characterized by Morrow Lake fish. In Exhibit 4, that blending is evident in the average peak PCB concentration ratios for various sections of the Kalamazoo River as ratios falling above those for Morrow Lake and below those for Bryant Mill Pond. This exhibit also presents the approximate line (50%/50%) representing equal proportions of the Aroclor 1242-derived and Aroclor 1254-derived PCB in fish. Fish plotting above that line would have most of their PCB composition derived from an Aroclor 1242-like mixture and fish plotting below that line would have most of their PCB composition derived from an Aroclor 1254-like mixture. Based upon my review of the PCB chromatograms for fish and this quantitative analysis, it is my opinion that roughly half of the PCB currently found in Kalamazoo River fish are derived from Aroclors other than Aroclor 1242, principally Aroclor 1254.

In contrast to the composition of PCB in fish, Aroclor 1254-derived PCB represents a comparatively smaller proportion of the total mass of PCB in the total volume of PCB-containing sediments of the Kalamazoo River. Consequently, the composition of PCB in fish and the related need for a CERCLA response cannot be simply apportioned based upon the direct proportion of the mass of Aroclor 1254-derived PCB in sediments.

As evident by 1) the clear evidence of a substantial contribution of Aroclor 1254 composition of PCB in Kalamazoo River fish and 2) the exclusive role of PCB in fish as determining the need for a CERCLA response at the Kalamazoo River Superfund Site, the release of Aroclor 1254 to the Kalamazoo River has played a substantial role in determining the need for a response.

As part of the work in completing the RI/FS for the Kalamazoo River, estimates of the quantity of PCB in river sediments were developed for each of nine sections of the Kalamazoo River from Morrow Lake through Lake Allegan. Using the results of analyses of sediment cores collected during the RI. These sections comprise approximately 50 miles of the Kalamazoo River. The total PCB mass estimates are presented in the attached Exhibit 5. As evident by Exhibit 5 Lake Allegan contains approximately 78 percent of the total PCB mass in the sediments of this section of the river. Lake Allegan also comprises approximately 64 percent of the entire river surface over

this 50 mile section. The PCBs quantified by the laboratory as either Aroclor 1254 or Aroclor 1260 comprise approximately 12 percent of the PCB mass in the sediments of Lake Allegan.

There are two reasons that the proportion of Aroclor 1254-derived PCB in the total volume of PCB-containing sediments is much smaller than the proportion of Aroclor 1254-derived PCB in fish. The first reason, which has been described previously, is that Aroclor 1254 is much more bioaccumulative than Aroclor 1242. The second reason is that the proportion of Aroclor 1254-derived of PCB in the surface sediments, which directly affects PCB bioaccumulation in fish, is much higher than the proportion of Aroclor 1254-derived PCB in the deeper sediments which are no longer influencing PCB concentrations in fish. This is illustrated through Exhibit 6.

The attached Exhibit 6 presents the chronology of PCB deposition in sediments in Kalamazoo Lake situated near the downstream end of the Kalamazoo River. These cores are the only cores collected downstream of Allegan which have acceptable ^{137}Cs patterns for use in estimating the age of sediment strata. Such cores are generally useful in conducting remedial investigations because they can provide for an assessment of temporal trends where other time series observations are lacking. All three cores exhibit similar significant features with respect to a transition in the relative importance of Aroclor 1254-like PCB. The majority of the total PCB mass in all of the cores is derived from Aroclor 1242 or similar mixtures (i.e., Aroclor 1016, Aroclor 1248). All cores show the trend of steeply declining Aroclor 1242 concentrations in sediments deposited since the mid-1970s to early 1980s. Since the peak in the late 1970s to the early 1980s, concentrations of Aroclor 1242-like PCB have been declining at faster rates than Aroclor 1254 PCB. The half times for the Aroclor 1254-quantified or Aroclor 1260-quantified PCB in these cores from the late 1970s range from 7.4 years (KL2-1) to 13.3 years (KL2-4) whereas half times for the PCBs quantified as the Aroclor 1242-like PCB range from 3.2 years (KL2-1) to 4.6 years (KL2-2). Finally, the proportion of Aroclor 1254-like PCB in surface sediment has been increasing.

For the cores represented in Exhibit 6, the 1990-1993 sediment strata represent 3 to 4 inches of near-surface sediment. Of that, the bioavailable zone is represented by perhaps as little as the top two inches of sediment. Within the top two inches, Aroclor 1254-like PCB (the laboratory did not quantify any PCB in the top two inches of these cores as Aroclor 1260) comprises 23 percent (cores K2-1, KL2-2) to 31 percent (core K2-4) of the total PCB mass. Those proportions are much greater than the proportions in deeper sediments which were formerly in the bioavailable zone. Today, the proportions of the more bioaccumulative Aroclor 1254-like PCB in the bioavailable zone of sediments are consistent with the findings of approximately half of the PCB in fish derived from Aroclor 1254 based upon the differences in the bioaccumulation of Aroclor 1242 and Aroclor 1254 PCBs. So, the disproportion in the levels of Aroclor 1254-like PCB to Aroclor 1242-like PCB in fish relative to their relative quantities in the total volume of sediment is not only related to the differences in their propensity to bioaccumulate but also is related to the greater proportions of Aroclor 1254-like PCB in bioavailable zone sediment than in the total volume of PCB-containing sediment.

The CERCLA response as required by the Michigan Department of Environmental Quality (MDEQ) has included the development and implementation of an investigation of the Kalamazoo River extending from areas upstream of the KRSG member facilities and downstream of the listed National Priorities List (NPL) site to Lake Michigan. The response also includes a number of tasks, with scopes that are independent of, or largely independent of, the geographic extent of the investigation.

As I have presented in my earlier April 7, 1997 report (Brown, 1997a) and the addenda to that report (Brown, 1997b; 1997c; 1998a; 1998b; 1998c) which are incorporated herein, the Remedial Investigation has included fish and water sampling from locations extending from upstream of KRSG member facilities to downstream of Lake Allegan. The investigation continues and there has been increased attention given to areas downstream of the NPL-listed site. Lake Allegan, which is downstream of the NPL site, has in its sediments the great majority of PCB remaining in sediments between Morrow Lake and the Dam at Lake Allegan. In correspondence dated June 11, 1999 (Cornelius, 1999), the MDEQ requested the sampling of sediments to determine the nature and extent of PCB in sediments between the dam forming Lake Allegan and Lake Michigan.

Certain required investigations and activities which are largely independent of the location of KRSG member facilities have been undertaken. Examples of such investigations and activities include:

- The summary of pertinent information available prior to the start of the remedial investigation and feasibility study (RI/FS);
- Development of the RI/FS Work Plan and related planning documents (e.g., Field Sampling Plan, Quality Assurance Plan, Data Management Plan, etc.);
- Development and management of site data base;
- Human health risk assessment;
- Ecological risk assessment;
- Support for the community participation program; and
- Overall management of the RI/FS including meetings with KRSG and the MDEQ.

Such generic activities as well as many aspects of what has been a whole-river investigation are being conducted irrespective of the location of KRSG member facilities.

References

The following supplements the references contained in my earlier reports, which are incorporated herein by reference.

Agency for Toxic Substances and Disease Registry (ATSDR), *Toxicological Profile for Polychlorinated Biphenyls (PCBs)*, Draft for Public Comments, December 1998.

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Brown, M.P., BBL, *Report Regarding the Environmental Response at the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site - Third Addendum to April 7, 1997 Report*, April 21, 1998a.

Brown, M.P., BBL, *Report Regarding the Environmental Response at the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site - Fourth Addendum*, April 27, 1998b.

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Cornelius, S.D., MDEQ, Letter to M.P. Brown, BBL re: performance of Phase II sediment sampling downstream of Lake Allegan, June 11, 1999.

Frame, G.M., "A Collaborative Study of 209 PCB Congeners and 6 Aroclors on 20 Different HRGC Columns, 2. Semi-quantitative Aroclor Congener Distributions," *J. Anal. Chem.*, No. 357, p. 714-722, 1997.

Parkerton, T.F., J.P. Connolly, R.V. Thomann, and C.G. Uchrin, "Do Aquatic Effects or Human Health End Points Govern the Development of Sediment-Quality Criteria for Nonionic Organic Chemicals?," *Environ. Toxicol. and Chem.*, Vol. 12, No. 3, p. 507-523, 1993.

Schulz, D.E., G. Petrick, and J.C. Duinker, "Complete Characterization of Polychlorinated Biphenyl Congeners in Commercial Aroclor and Clophen Mixtures by Multidimensional Gas Chromatography - Electron Capture Detection," *Environ. Sci. Technol.*, Vol. 23, No. 7, p. 852-859, 1989.

Shiu, W.Y. and D. Mackay, "A Critical Review of Aqueous Solubilities, Vapor Pressures, Henry's Law Constants, and Octanol-Water Partition Coefficients of the Polychlorinated Biphenyls," *J. Phys. Chem. Ref. Data*, Vol. 15 No. 2, 1986.

Exhibits List

1. Relationship Between Biota to Sediment Accumulation Factors (BSAFs) and the Logarithm of Octanol-Water Partition Coefficients (Log K_{ow}).

2. PCB Chromatogram Peaks A/G PCB Concentration Ratio vs. Total PCB Concentration - Kalamazoo River Fish 1993 Data.

3. PCB Chromatogram Peaks A/K PCB Concentration Ratio vs. Total PCB Concentration - Kalamazoo River Fish 1993 Data.

4. PCB Chromatogram Peaks A/G and A/K PCB Concentration Ratio Averages - Kalamazoo River Fish 1993 Data.

5. Area and PCB Mass in Kalamazoo River Sediment.

6. Kalamazoo River PCB Deposition Chronologies from Cores Collected in Kalamazoo Lake.

Exhibit 1

Relationship Between Biota to Sediment Accumulation Factors (BSAFs) and the Logarithm of Octanol-Water Partition Coefficients (Log Kow)

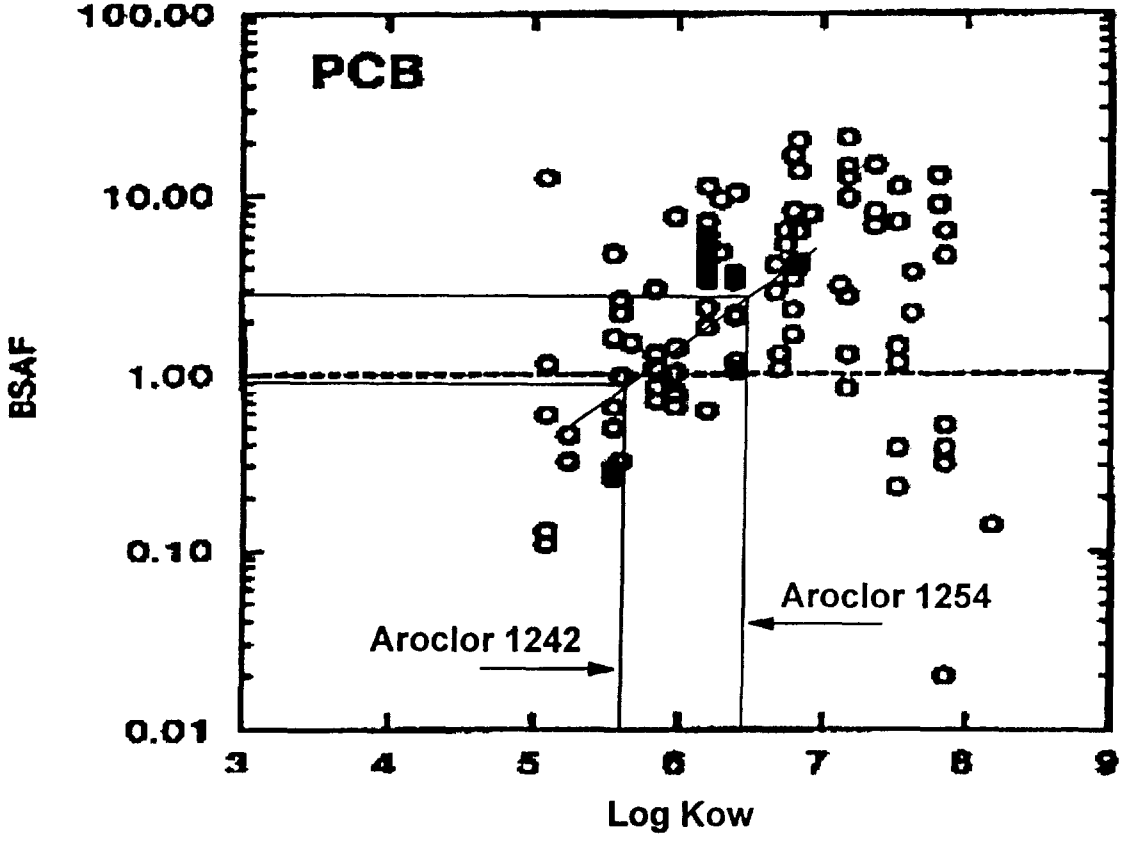
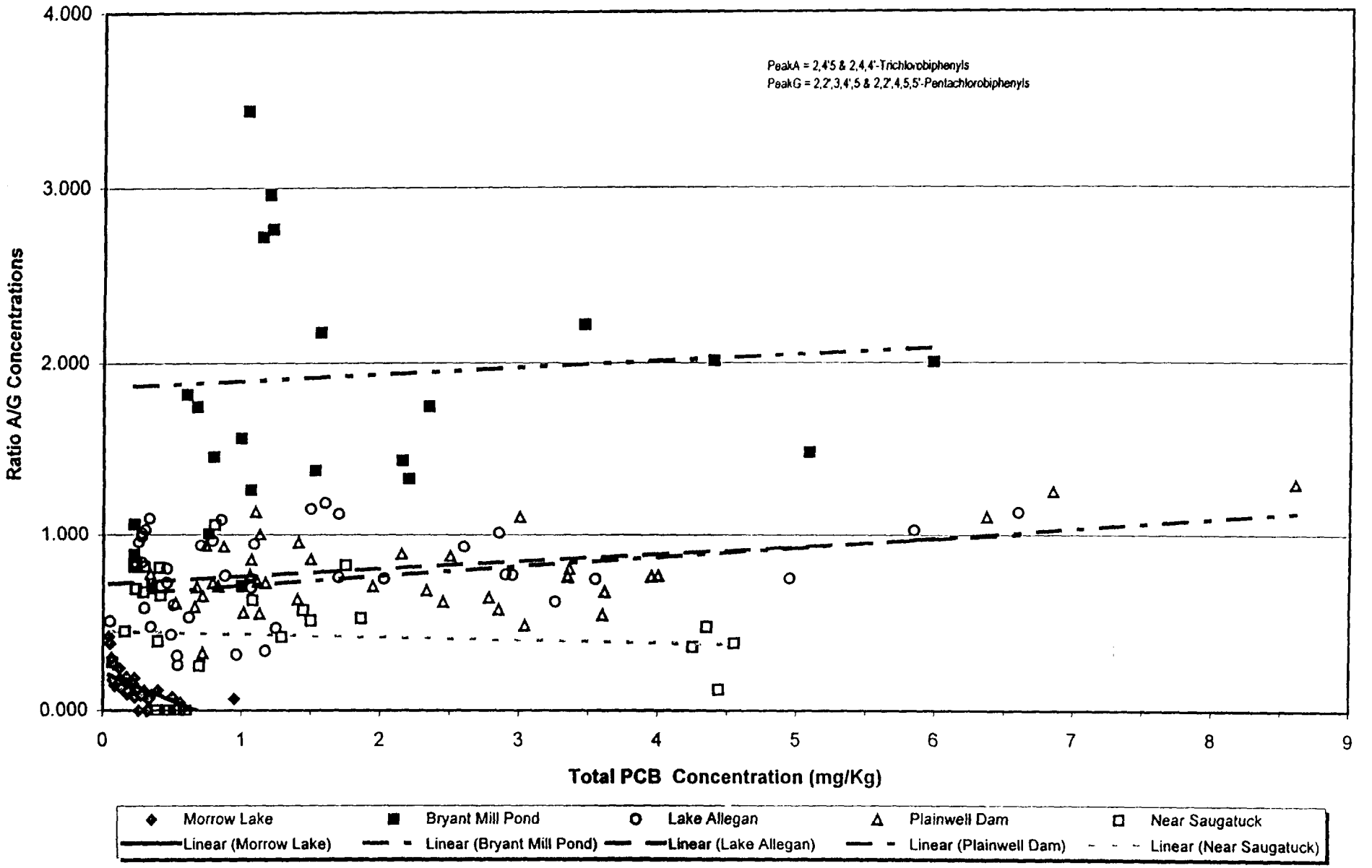


Exhibit 2

PCB Chromatogram Peaks A/G PCB Concentration Ratio vs Total PCB Concentration

Kalamazoo River Fish 1993 Data



ajz: f:\filexchg\div12\kzoo\Exhibits - AG Ratio vs TPCB

Exhibit 3
PCB Chromatogram Peaks A/K PCB Concentration Ratio vs Total PCB Concentration
Kalamazoo River Fish 1993 Data

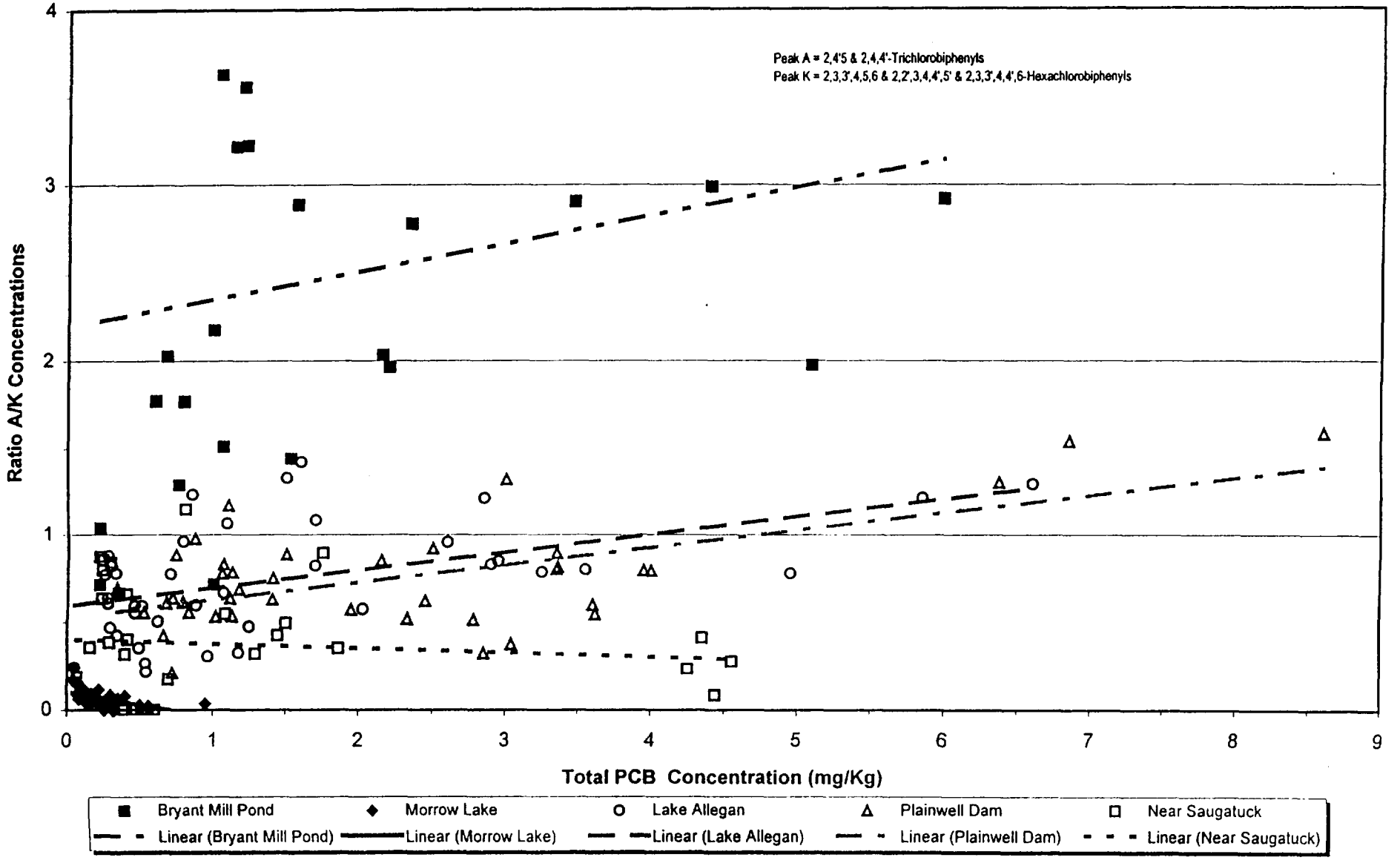


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Exhibit 4
PCB Chromatogram Peaks A/G and A/K PCB Concentration Ratio Averages
Kalamazoo River Fish 1993 Data

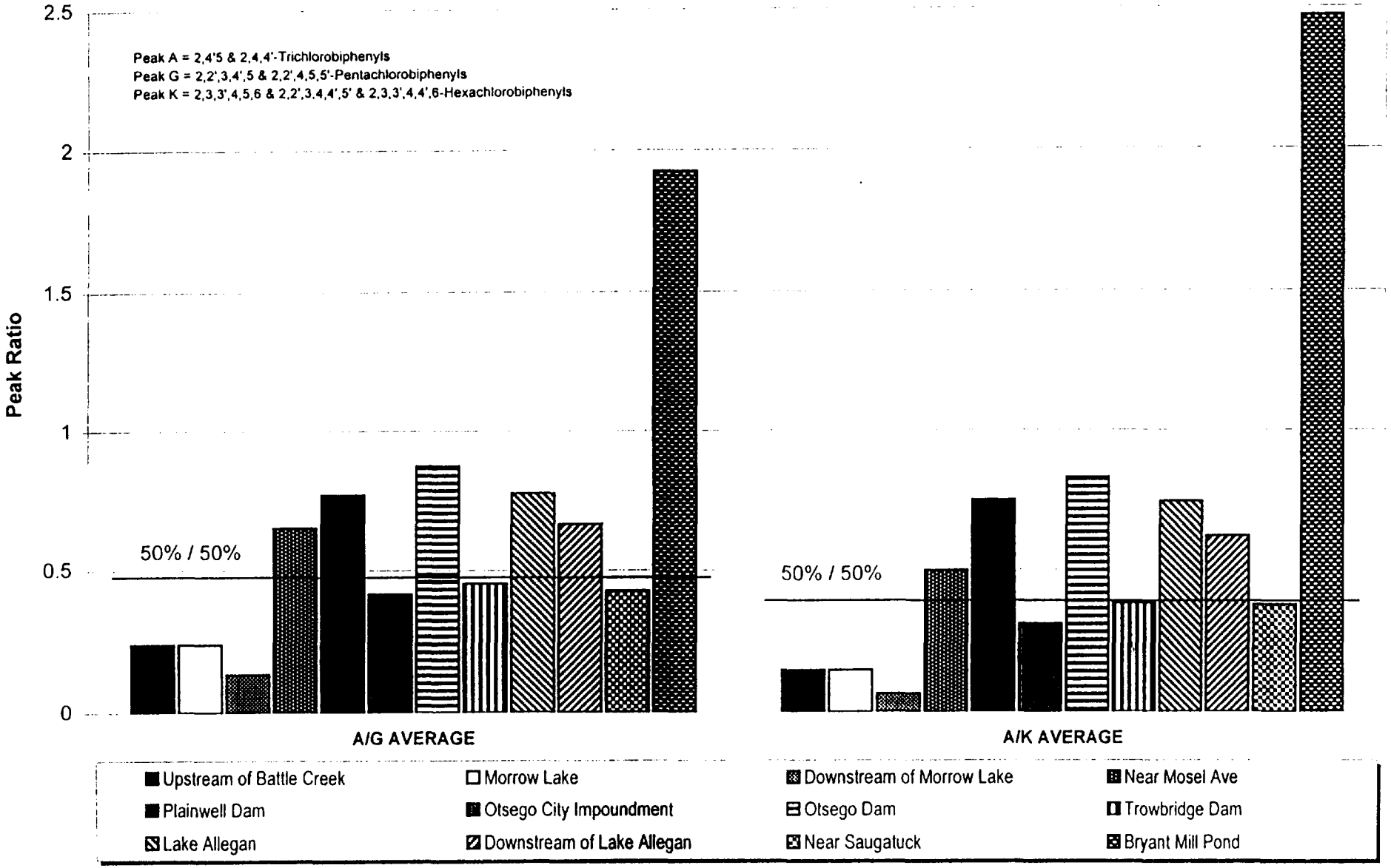

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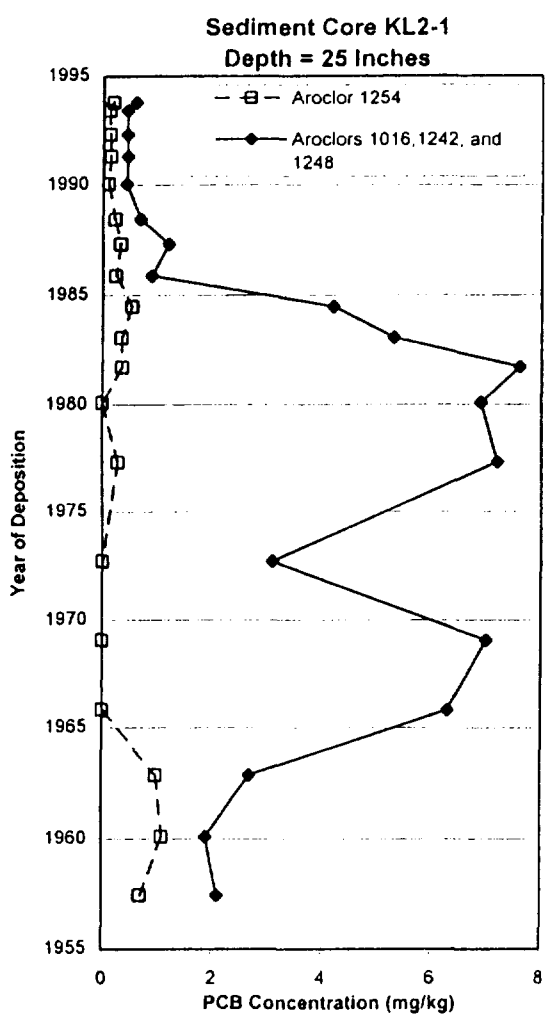
Exhibit 5

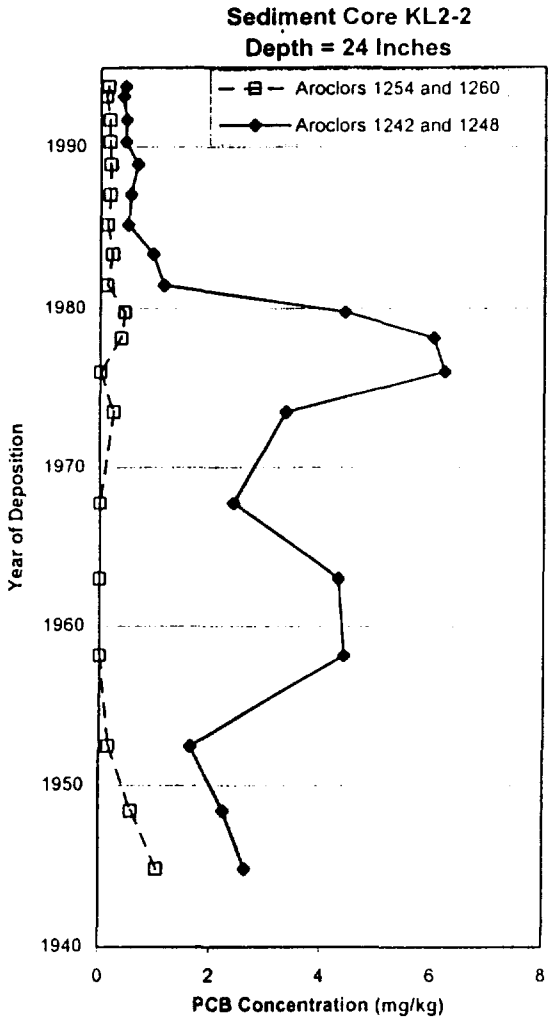
Sediment Surface Area and PCB Mass in Kalamazoo River Sediment

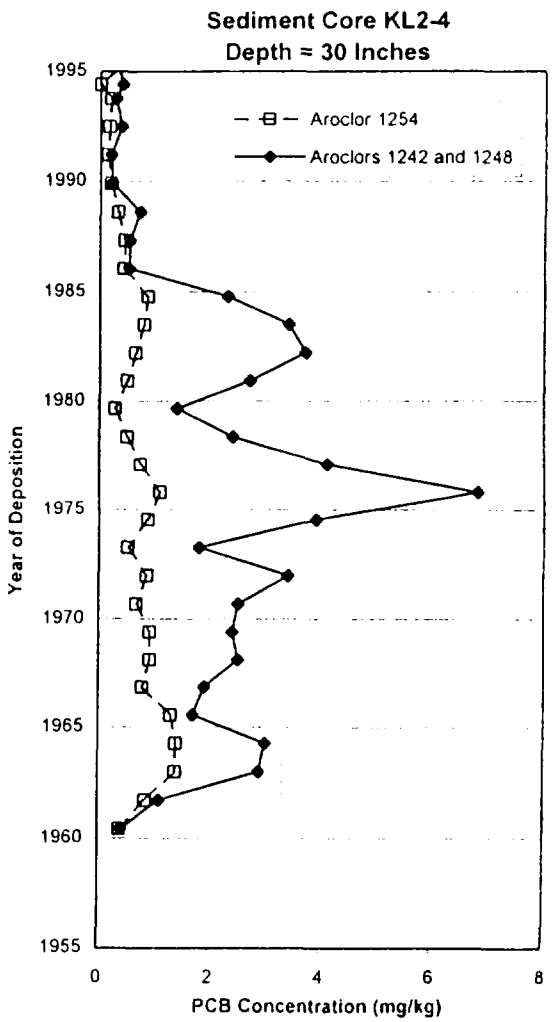
		Area (acres)	PCB Mass (kg)
A1	Morrow Dam to Portage Creek Confluence	84	777
A2	Portage Creek Confluence to Main Street Plainwell	338	456
B	Main Street, Plainwell to Plainwell Dam	48	655
C	Plainwell Dam to Otsego City Dam	93	751
D	Otsego City Dam to Otsego Dam	80	377
E	Otsego Dam to Trowbridge Dam	121	598
F	Trowbridge Dam to Allegan City Line	171	472
G	Allegan City Line to Allegan City Dam	116	2,245
H	Allegan City Dam to Allegan Dam	1,901	22,637
	Totals	2,952	28,968

Exhibit 6

Kalamazoo River PCB Deposition Chronologies from Cores Collected in Kalamazoo Lake







Section 5

Report Regarding the Environmental Response at the Allied Paper Inc./ Portage Creek/Kalamazoo River Superfund Site Seventh Addendum to April 7, 1997 Report

Allied Paper Inc./Portage
Creek/Kalamazoo River Superfund Site

December 28, 2000

Mark P. Brown, Ph.D.
Blasland, Bouck & Lee, Inc.

1. Introduction

This report supplements my April 7, 1997 expert report (Brown, 1997) and my subsequent addenda to that document, all of which are incorporated herein by reference, by presenting additional information that further supports the conclusions, observations, and opinions stated in those reports regarding the discharge of polychlorinated biphenyls (PCB) by Eaton Corporation to the Kalamazoo River. I understand that Eaton's counsel is making available additional PCB sampling data taken at the Eaton Kalamazoo facility site by the MDEQ, but that Eaton's counsel has not yet been able to supply information to precisely where the samples were taken. I reserve the right to examine this data (once it becomes available) and supplement my opinions based on that review.

In my opinion, the facts, observations, and conclusions in this document are true to a reasonable degree of scientific certainty.

2. PCB in Kalamazoo River Sediment

I have reviewed the PCB data for the Kalamazoo River in the vicinity of Eaton Corporation's former manufacturing facility in Kalamazoo, Michigan and have concluded that PCB concentrations and compositions vary so greatly over such small distances that even a relatively large contribution of PCB by the Eaton Kalamazoo facility might not be discernable in the current data for the Kalamazoo River. In my opinion, this observation applies to other sections of the river including the section of the river near Eaton Corporation's former Battle Creek facility.

In preparing this expert report, I examined the data for sediment samples collected generally upstream and downstream of the location where Eaton's Kalamazoo facility discharged to the river. As part of the Remedial Investigation for the Kalamazoo River Superfund Site, sediment cores were collected from various locations. The great majority of these samples were collected along lines called transects extending across the river. Cores were collected by pushing a plastic tube into the sediment. The sediments in the core tube were divided into various layers and shipped for chemical analysis. The layers that were analyzed generally included the 0-2 inch layer which is also referred to as the surface layer, the 2-6 inch layer and 6-12 inch layer. Deeper layers were sometimes analyzed; the number of layers and thickness of the layers depended on the length of core. The analyses included PCBs and for a large number of samples Total Organic Carbon (TOC) content. More specifically, I examined the data for two upstream and three downstream transects shown on the map in Exhibit 1. Exhibit 1 also shows the approximate location of the outfall of the Richardson Drain through which Eaton discharged wastes to the Kalamazoo River.[1]

It became readily apparent that the wide variations in both PCB concentrations in sediment and the composition of PCBs within the upstream samples and within the downstream samples meant that such upstream and downstream comparisons would be insensitive to detecting even rather large historic releases of PCB from the Eaton facility.

[1] Although the Zantman Drain and the Richardson Drain have been the focus of much of the attention regarding Eaton's discharge to the Kalamazoo River, I have recently become aware of Mr. Kenneth P. Collard's February 2, 1998 affidavit regarding storm sewer discharge to the river. Mr. Collard's affidavit, along with Mr. David Martin's 1997 deposition, establish a second pathway of Eaton's waste discharge to the river.

2.1 The Section of the Kalamazoo River Into Which Eaton Discharged Retains Relatively Little of the PCB it Once Transported

Relatively little of the PCB that was discharged by Eaton is expected to remain in this section of the River. The relatively swift moving sections of the Kalamazoo River such as that to which the Eaton facility discharged tended to transport rather than deposit PCBs. As shown in the Remedial Investigation Report, the great majority of PCB is deposited in impoundments rather than the relatively swift flowing section of the Kalamazoo River such as the section from the city of Kalamazoo to Plainwell. Indeed, the section of the Kalamazoo beginning at the former Plainwell Impoundment and extending through Lake Allegan, contains an estimated 40,700 kg of PCB. In contrast, the fast flowing 20-mile section of the Kalamazoo River from the Morrow Dam to Plainwell contains an estimated 1,100 kg of PCB. With regard to the ability of this section of river to efficiently transport PCB to downstream areas, it is noteworthy that three of the four Plaintiffs' facilities are either located along the Kalamazoo River or discharged to a tributary which entered the Kalamazoo River upstream of the Eaton facility.

2.2 The Composition of PCBs in Sediments Near Eaton Varies Substantially

The composition of PCB in sediment varies substantially over short distances both upstream and downstream of the Eaton facility discharge. At transect KPT23 located a short distance upstream of Mosel Avenue (Exhibit 1) the 12-20 inch section of core KPT23-7 contained a PCB concentration of 67 mg/kg. Its chromatogram (Exhibit 2b) reflected a pattern of remarkably unaltered Aroclor 1254 with no other Aroclor-derived PCB. The chromatogram (Exhibit 2a) for the sediment layer immediately above this layer showed a very clear mixture derived from Aroclor 1242 and Aroclor 1254. The corresponding Aroclor 1242 and Aroclor 1254 standard chromatograms are presented in Exhibit 3a and 3b. Total PCB in this second sample was quantified as roughly equal amounts of Aroclor 1242 and Aroclor 1254. Elsewhere along the same transect, most of the PCB was quantified as Aroclor 1242 or Aroclor 1248 with smaller amounts of Aroclor 1254 and Aroclor 1260. Thus, as illustrated by the chromatograms for the upstream samples in Exhibit 2, on a vertical scale of inches, the composition of PCBs can vary dramatically.

Downstream of Eaton at transects KPT25, KPT26 and KPT27 there also is a wide range in PCB composition in sediments over relatively short distances. In core KPT25-8 the 0-2 inch layer sample had a PCB composition (Exhibit 4a) reflecting a mixture of Aroclor 1242, Aroclor 1254 and Aroclor 1260-derived PCB compounds that has been slightly altered by dechlorination in a pattern previously observed and described in the Remedial Investigation Report. For this sample, the ratio of the sum of Aroclor 1242 and Aroclor 1248-quantified PCB to the sum of Aroclor 1254 and Aroclor 1260 quantified PCB is 2.3:1. In the sample just below this layer, the same

ratio was 4.3:1. The chromatogram for the 2-6 inch layer (Exhibit 4b) reflects much more extensive dechlorination. The corresponding Aroclor 1242 and Aroclor 1254 standard chromatograms are presented in Exhibits 5 and 5b. As evident by Exhibits 2 and 4, the composition of PCB downstream of the Eaton facility varies greatly over small distances.

The composition of PCB that was discharged by Eaton was not unique to the Kalamazoo River and would have blended into mixtures seen in the river. For example, Aroclor 1254 and Aroclor 1260-derived PCB evident in samples recently collected by Dr. Michael McLaughlin are also present in the river upstream of the Eaton facility.

2.3 PCB Concentrations in Sediment Vary Greatly

PCB concentrations in sediment samples collected in the vicinity of Eaton Corporation's Kalamazoo facility vary so much over small distances that real differences between upstream and downstream mean PCB levels that might be indicative of the contribution of Eaton are obscured. Exhibit 6 presents the PCB concentration data for samples collected along transects KPT23, KPT24, KPT25, KPT26 and KPT27. Available wastewater discharge records (KB2201859) indicates that Eaton's discharge to the Zantman drain would have entered the Kalamazoo River between transects KPT24 and KPT25. In Exhibit 6, the range of reported PCB concentrations at upstream as well as at the downstream locations varies by more than a factor of 100 along single transects. The confidence limits in geometric means, which are better estimates of central tendency for these data than arithmetic averages, are also illustrated in Exhibit 6. In addition to illustrating the lack of statistically significant differences between upstream and downstream locations, they also indicate that even if the geometric mean concentration doubled downstream of Eaton as a result of their discharge, the effect would not be statistically discernable from these data. There is too much variation to the data for this to be discernable. A simple way to view this would be to consider how high the downstream bars in Exhibit 6 would need to be raised in this figure before there would be no overlap with bars corresponding to the upstream area.

One of the sources of variation is probably related to the differences in sediment grain size within a transect. In general, coarser sediments which have larger grain size and lower PCB concentration tend to be found toward the center of the river in this area. In contrast, finer sediments with smaller grain size and having higher PCB content and are found close to the edge of the river. This has been shown in the Remedial Investigation report for the river. One possible way of controlling for this effect is to adjust PCB concentrations to some other parameter that similarly varies with sediment grain size such as TOC. However, even after adjusting PCB concentrations by TOC content, the data are still quite variable and geometric means are still insensitive to detecting upstream and downstream differences.

To illustrate the degree of insensitivity of total PCB and TOC-adjusted PCB concentrations to detecting PCB loading from Eaton Corporation's Kalamazoo facility, the upper 95% confidence limits were estimated using data pooled for transects KPT23, KPT24, KPT25, KPT26 and KPT27. Pooling all of the data has the effect of reducing the confidence band around the geometric mean to be smaller than that for the smaller data pools upstream and downstream data. The data from the subset of surface samples was also analyzed. The results are summarized in the table below.

Table 1

PCB Levels in Sediments at Transects KPT23, KPT24, KPT265, KPT26 and KPT27

Assessment of Measurement Sensitivity

Parameter	Data Subset	n[1]	Geometric Mean (mg/kg)	Upper 95% Confidence Limit (mg/kg)	Percent[2] Increase
PCB	All Depths	98	0.15	0.22	47
PCB	Surface	33	0.21	0.39	86
PCB/TOC	All Depths	91	27	42	56
PCB/TOC	Surface	33	21	38	86

Notes: [1] n = number of samples

[2] Increase in mean concentration to upper confidence limit

The column labeled "Percent Increase" illustrates the magnitude of an increase in the measured parameter that could be caused by Eaton's discharge and still be statistically undetected due to the variations in the measurements for the given number of samples. Substantial increases, ranging from 47 to 86 percent, depending upon the parameter used for measurement, could go undetected. This is a general limitation of the Remedial Investigation data when applied to the problem of detecting the effect of a specific historical point source to the Kalamazoo River: the data tend to be too variable to distinguish the effects of a single point source on total PCB concentration.

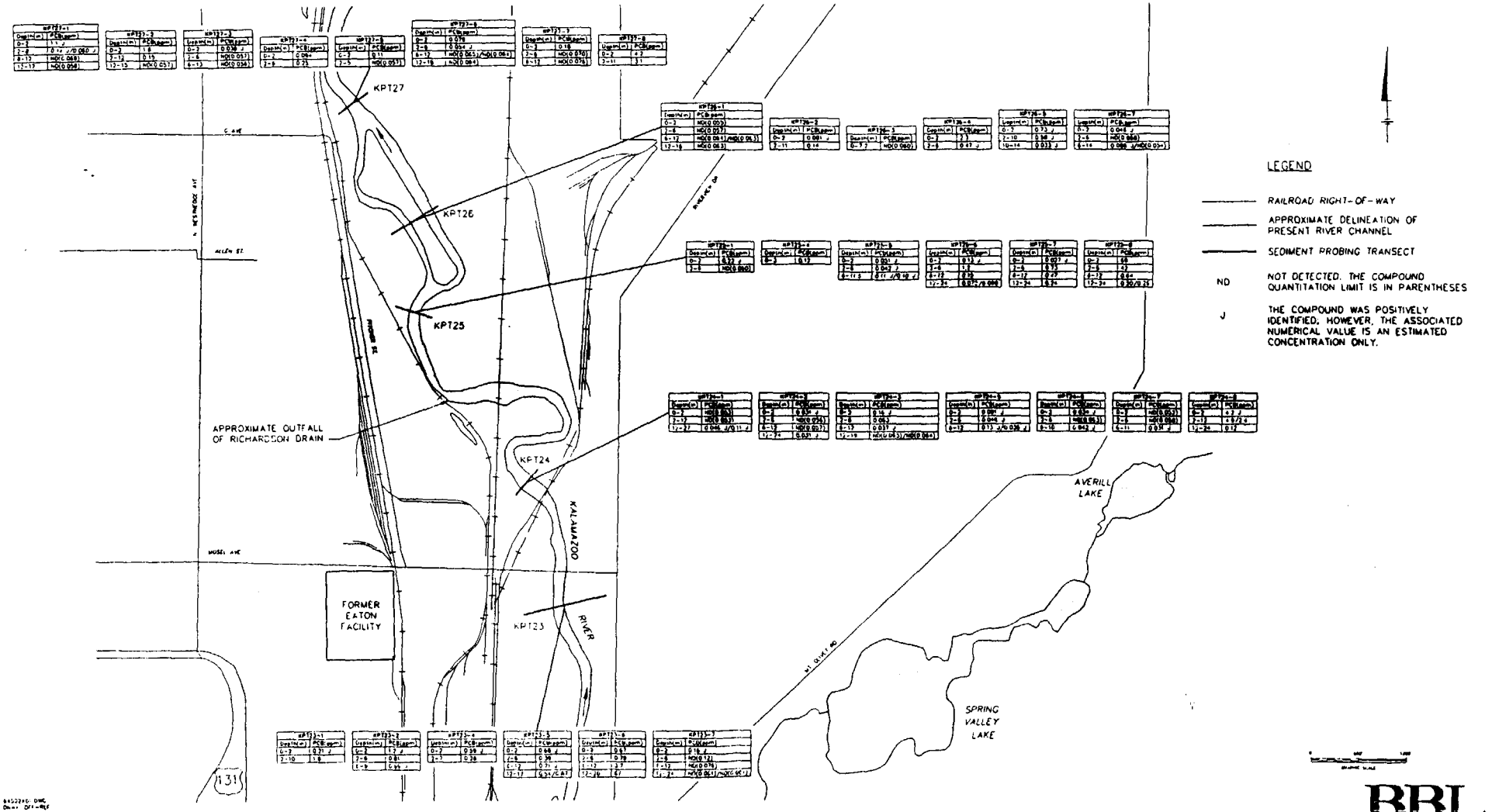
3. Conclusion

The Remedial Investigation sediment data are insensitive to even a relatively large amount of historic discharge of PCB from the Eaton facility. This is based on consideration of:

1) The character of the Kalamazoo River in the vicinity of Kalamazoo which strongly favored the transport of PCB to downstream areas rather than deposition of PCB in local sediments;
2) The presence of both Aroclor 1242-derived and Aroclor 1254-derived PCB both upstream and downstream of Eaton's discharge location to the Kalamazoo River;
3) The wide variations in ratios of Aroclor 1242-derived PCB to Aroclor 1254-derived PCB both upstream and downstream of the discharge;
4) Eaton discharged a mixture of PCB which was not unique to the Kalamazoo River; and
5) The wide variations in total PCB concentrations and TOC-adjusted PCB concentrations.

Consequently, the absence of statistically significant differences in PCB concentration or differences in PCB composition patterns is neither a compelling nor scientifically valid basis for a conclusion that Eaton did not discharge PCB to the Kalamazoo River. On the contrary, I remain convinced that Eaton's facility in Kalamazoo as well as those in Marshall and Battle Creek contributed PCB to the Kalamazoo River Superfund Site as stated in my earlier reports and addenda.

Exhibit 1 - Map of Kalamazoo River in Vicinity of Eaton Corporation's Kalamazoo Facility



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Conclusion

Remedial Investigation sediment data are insensitive to even a relatively large amount of historic discharge CB from the Eaton facility. This is based on consideration of:

The character of the Kalamazoo River in the vicinity of Kalamazoo which strongly favored the transport of PCB to downstream areas rather than deposition of PCB in local sediments;

The presence of both Aroclor 1242-derived and Aroclor 1254-derived PCB both upstream and downstream of Eaton's discharge location to the Kalamazoo River;

The wide variations in ratios of Aroclor 1242-derived PCB to Aroclor 1254-derived PCB both upstream and downstream of the discharge;

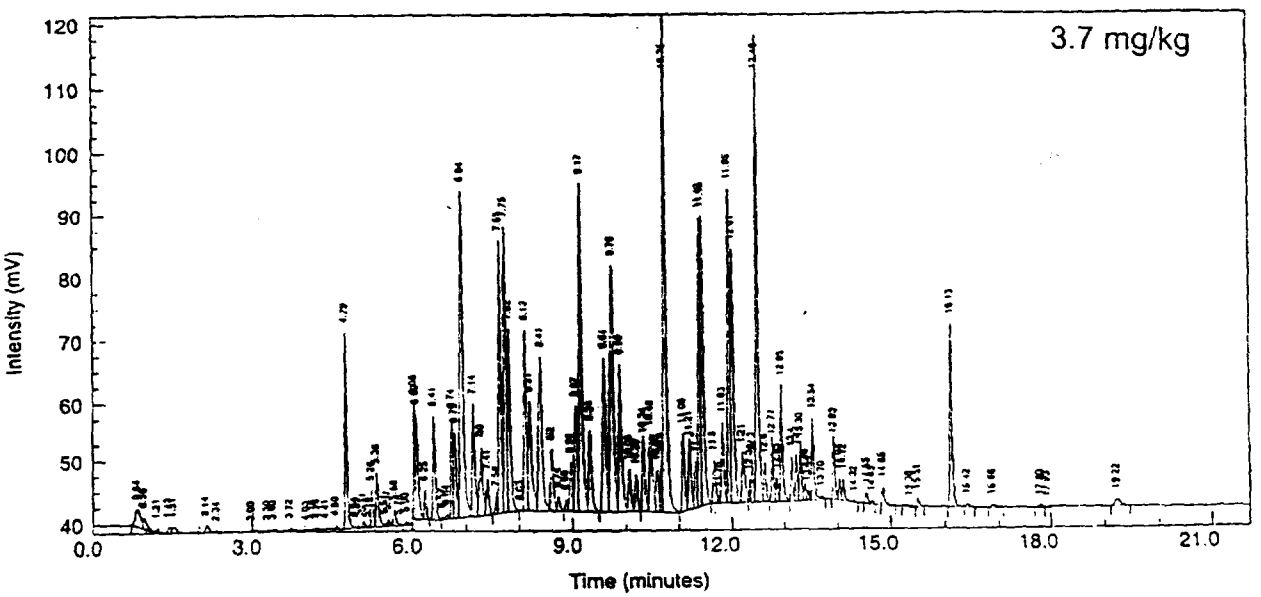
Eaton discharged a mixture of PCB which was not unique to the Kalamazoo River; and

The wide variations in total PCB concentrations and TOC-adjusted PCB concentrations.

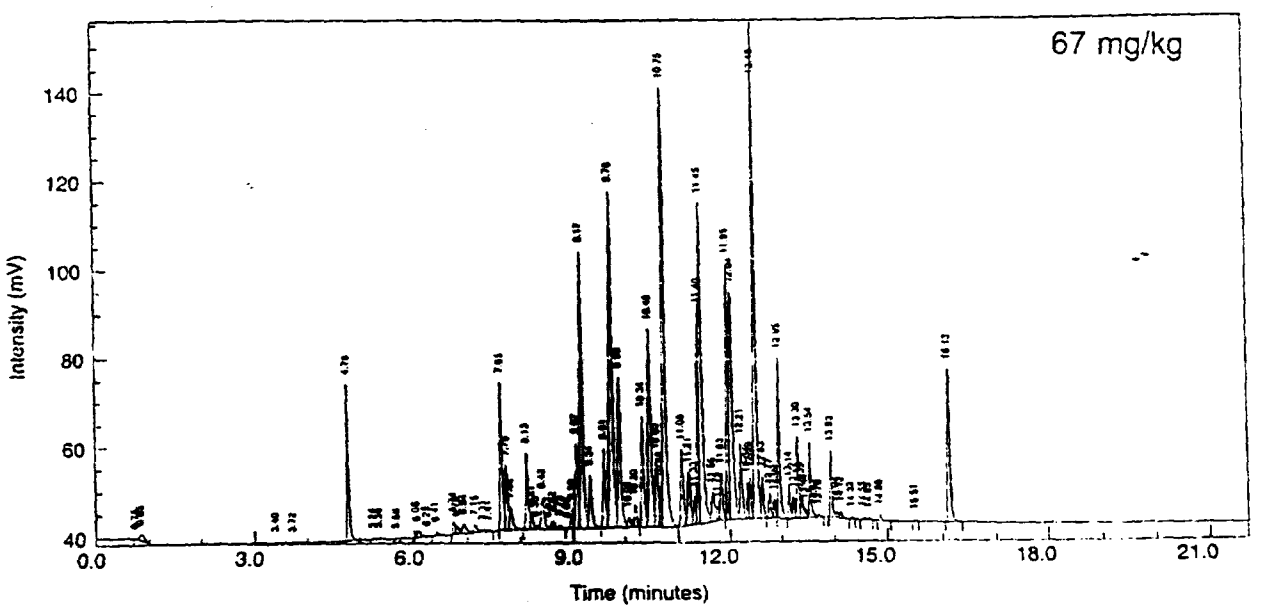
nsequently, the absence of statistically significant differences in PCB concentration or differences in PCB nposition patterns is neither a compelling nor scientifically valid basis for a conclusion that Eaton did not charge PCB to the Kalamazoo River. On the contrary, I remain convinced that Eaton's facility in Kalamazoo well as those in Marshall and Battle Creek contributed PCB to the Kalamazoo River Superfund Site as stated my earlier reports and addenda.

Exhibit 2

Chromatograms for Sediment
Samples Upstream of the Eaton Corporation
Kalamazoo Facility



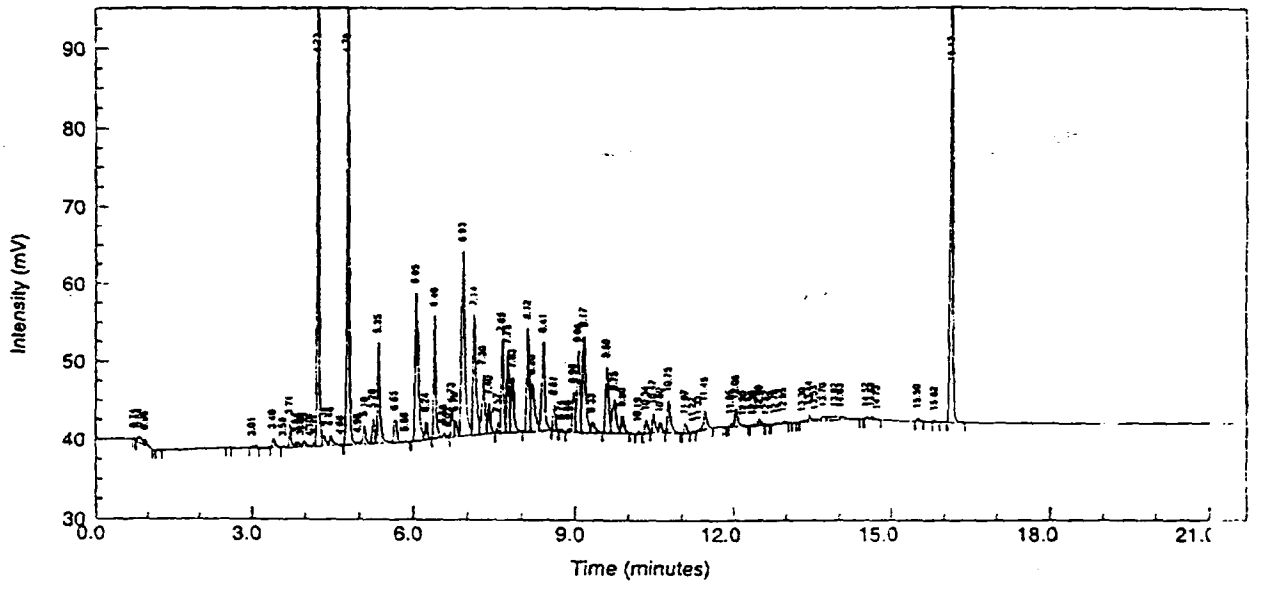
a. core KPT23-6, 6-12-inch layer



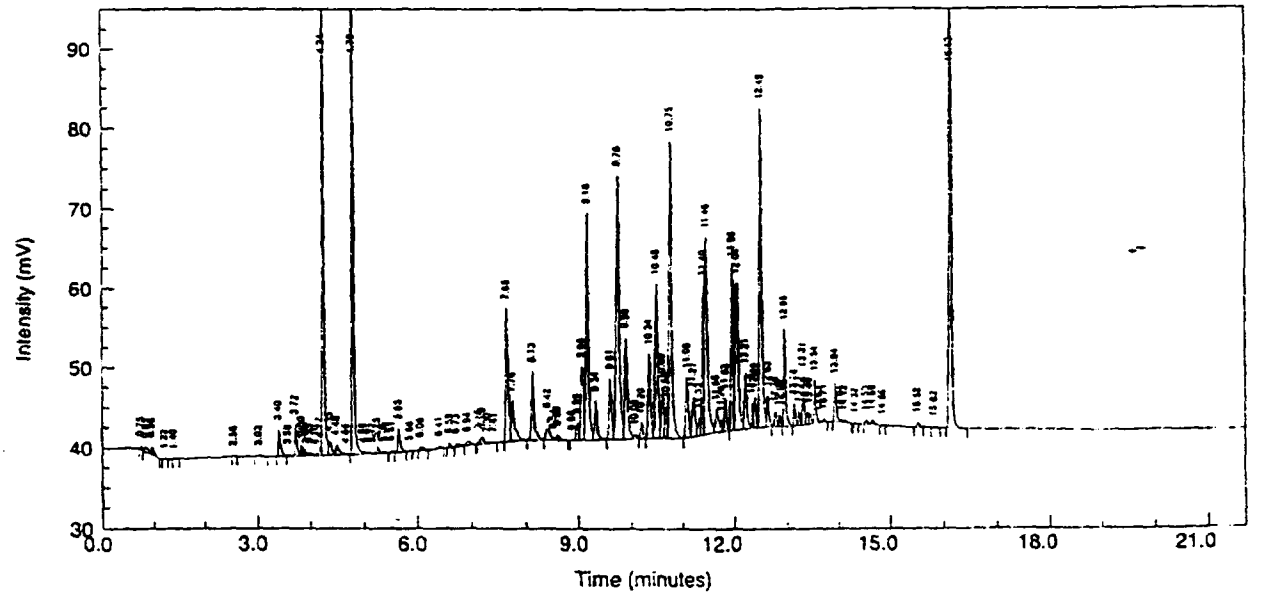
b. core KPT23-6, 12-20-inch layer

Exhibit 3

Chromatograms for Aroclor Standards
Corresponding to the Chromatograms
in Exhibit 2

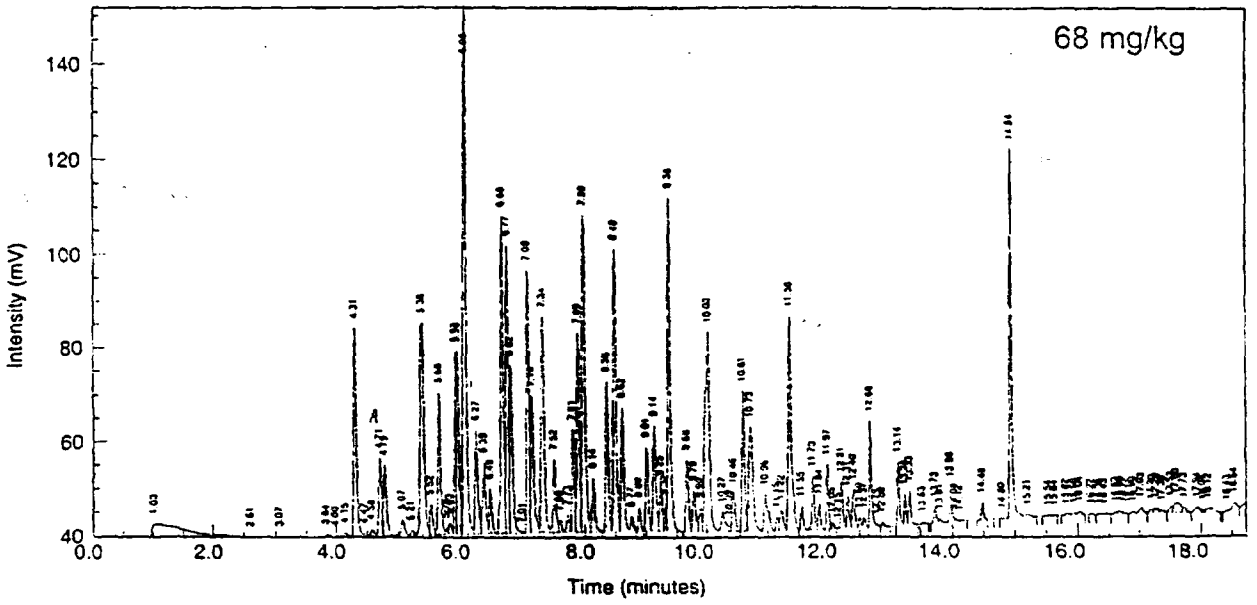


a. Aroclor 1242

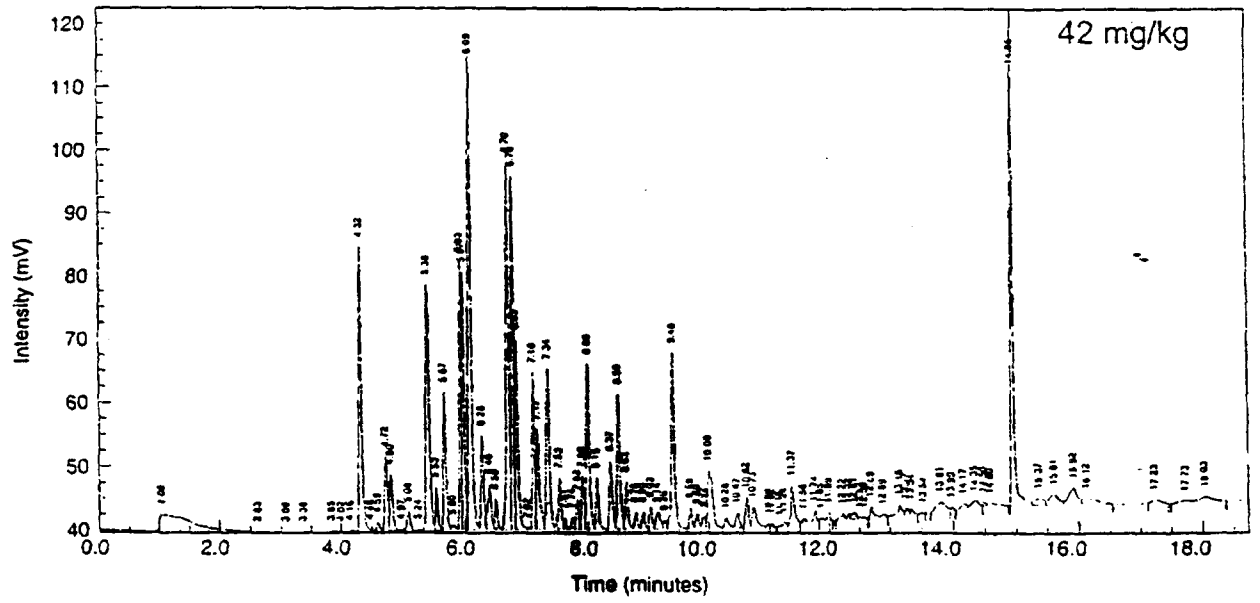


b. Aroclor 1254

Chromatograms for Sediment Samples Downstream of the Eaton Corporation Kalamazoo Facility



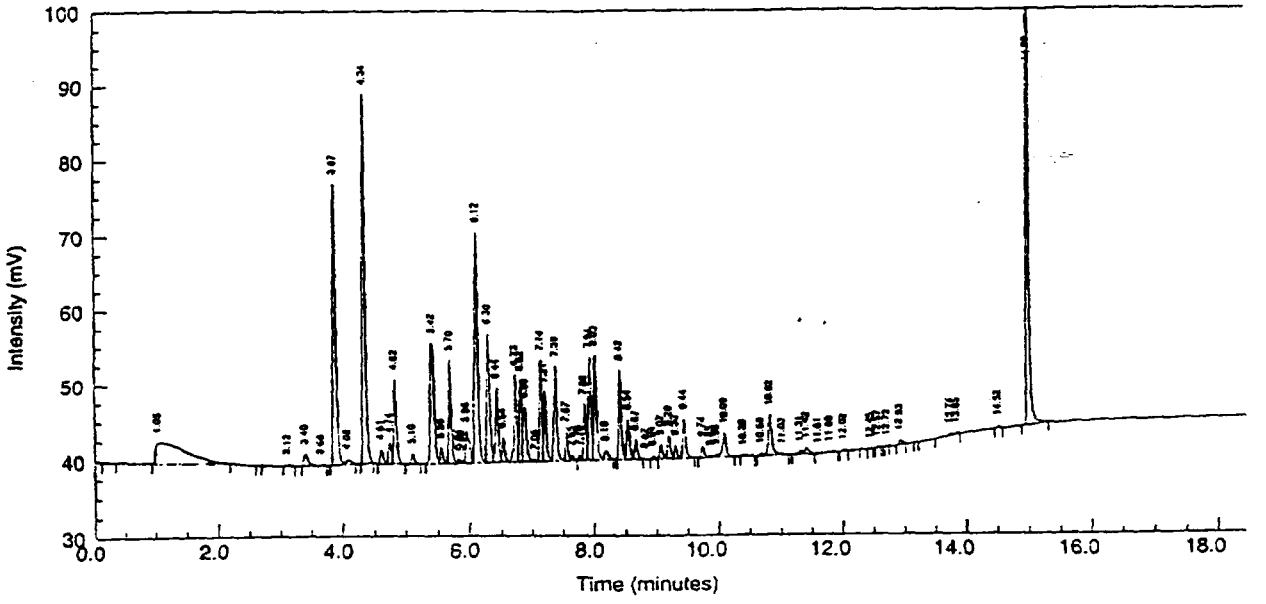
a. core KPT25-8, 0-2-inch layer



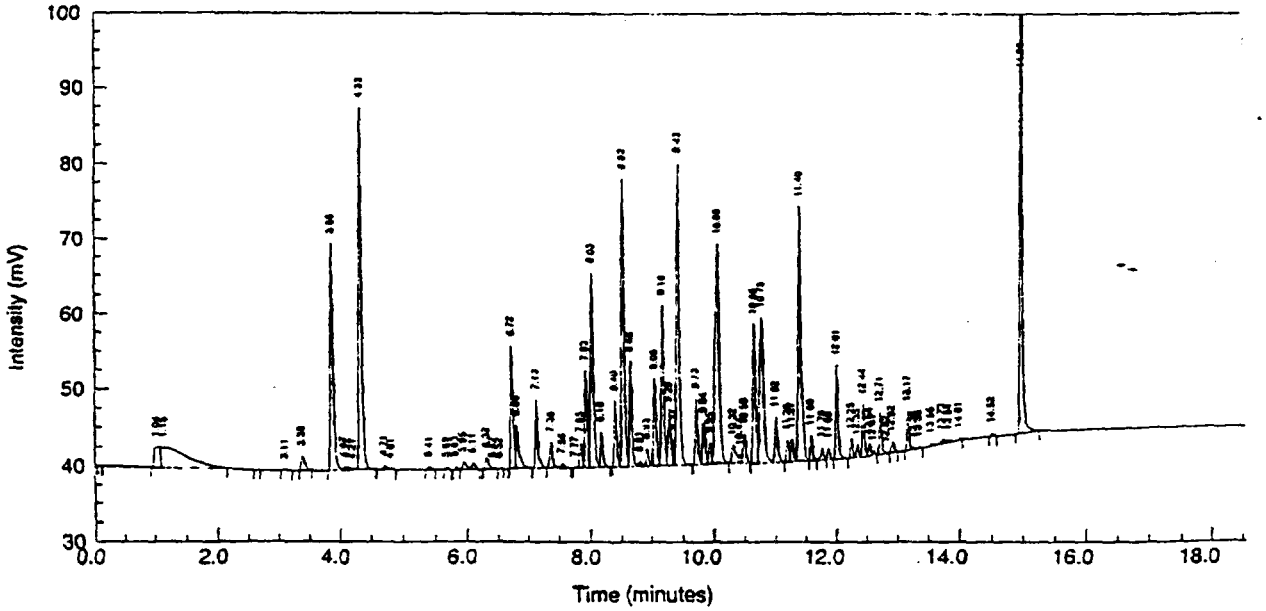
b. core KPT25-8, 2-6-inch layer

Exhibit 5

Chromatograms for Aroclor Standards
Corresponding to the Chromatograms
in Exhibit 4



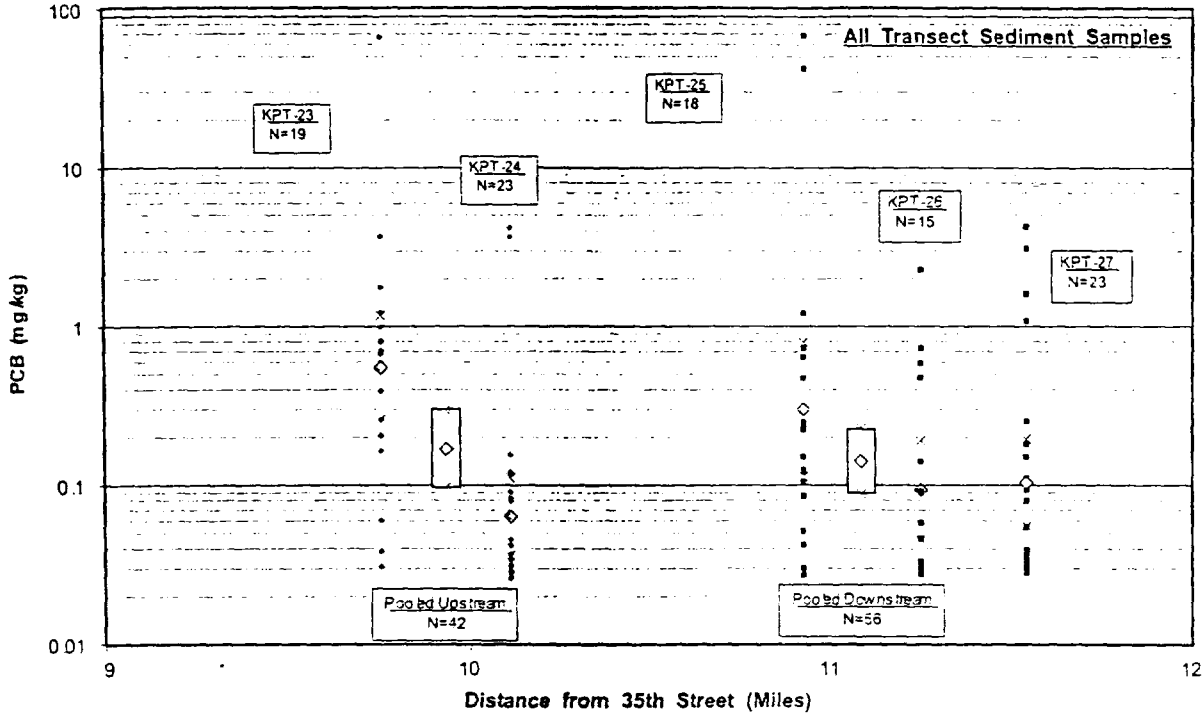
a. Aroclor 1242

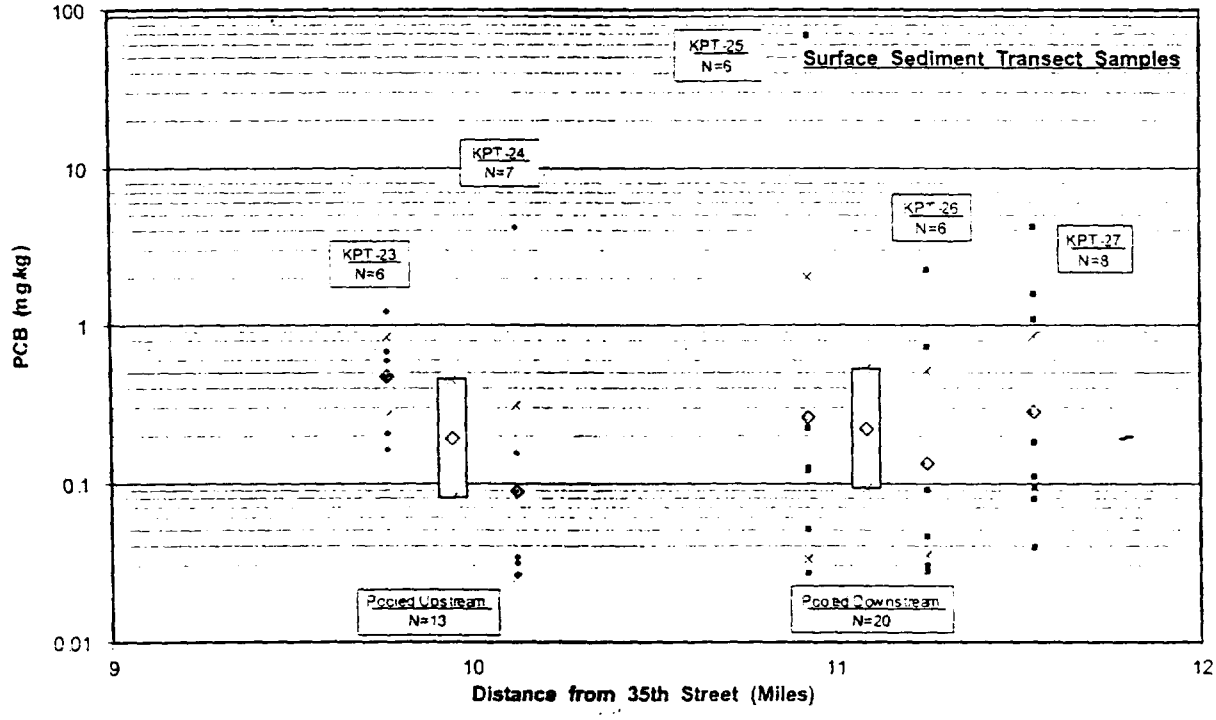


b. Aroclor 1254

Exhibit 6

PCB Concentrations in Kalamazoo River Sediment Upstream and Downstream of The Eaton Corporation Kalamazoo Facility





LEGEND:

- Upstream of Eaton Facility
- Downstream of Eaton Facility
- Geometric Mean
- 95% Confidence Limits on Geometric Mean

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Section 6

Report Regarding the Environmental Response at the Allied Paper, Inc./ Portage Creek/Kalamazoo River Superfund Site Eighth Addendum to April 7, 1997 Report

This report is submitted in support of the litigation initiated by the members of the Kalamazoo River Study Group. This report summarizes my opinions and testimony which rely upon: my experience and education, the highlights of which were summarized in Section 1 of the April 7, 1997 report; the information generated during the Remedial Investigation of the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site; the exhibits described in and provided with this and my other reports; and the documents produced in this case.

Mark P. Brown, Ph.D.

Allied Paper, Inc/Portage Creek/Kalamazoo River Superfund Site

October 9, 2001

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Table of Contents

1. Introduction

This report supplements my April 7, 1997 expert report (Brown, 1997a), and my addenda dated September 15, 1997 (Brown, 1997b), December 18, 1997 (Brown, 1997c), April 21, 1998 (Brown, 1998a), April 27, 1998 (Brown, 1998b), May 4, 1998 (Brown, 1998c), July 1, 1999 (Brown, 1999), and December 28, 2000 (Brown, 2000), including all exhibits, attachments, and references to those reports. This report also supplements my testimony given at trial regarding the Kalamazoo River Study Group's liability claims against Eaton Corporation (Brown, 1998d; 2001). This report presents additional information that further supports the conclusions, observations, and opinions stated in my earlier reports and testimony. All of my earlier reports, as well as my trial testimony, are incorporated herein by reference.

In my opinion, the facts, observations, and conclusions in this document are true to a reasonable degree of scientific certainty.

2. Background of Mark P. Brown, Ph.D.

The following supplements my background information contained in my earlier reports, which are incorporated herein by reference.

2.1 Present Job Title

I am currently a Senior Vice President of Blasland, Bouck & Lee, Inc. (BBL) in the company's office in New Bedford, Massachusetts. I was promoted to this position in January 1998.

2.2 Compensation

The Kalamazoo River Study Group (KRSG) is compensating BBL at a rate of $200 per hour for my services in this matter.

2.3 Depositions

Depositions or trial testimony were provided in the last 10 years in matters other than the case:

1. Dyer v. Monsanto Corporation. St. Clair County, Alabama, CV933-250 (1999 deposition only).

2. Maine People's Alliance and Natural Resources Defense Counsel, Inc. v. Holtra Chem Manufacturing Co. LLC and Mallinckrodt Inc. Civil Action No. 00-69-B United States District Court, District of Maine July 26, 2001. Deposition.

3. Sabrine Abernathy et al. v. Monsanto Corporation et al. Civil Action No. CV 2001-832. Circuit Court for Etowah County, Alabama. September 6, 2001 Deposition.

3. Discussion

Eaton Corporation (Eaton) contributed substantially to the levels of polychlorinated biphenyls (PCB) in fish and sediment in the Kalamazoo River and consequently affected the costs incurred by KRSG to conduct the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) for the Kalamazoo River Superfund Site (Site). This report provides information regarding the extent of Eaton's contribution of PCB to the Site and the consequent response costs. The type of PCB discharged by Eaton contributes proportionately more to the PCB levels in fish than the contributions from KRSG facilities. As presented in my July 1, 1999 report addendum (Brown, 1999), PCB levels in fish are the primary reason that any CERCLA response has been necessary at the Kalamazoo River Superfund Site. As I have also testified previously, Aroclor 1254 contributed by sources other than KRSG facilities accounts for approximately half of the PCB found in fish at the Site downstream of Morrow Lake.

Eaton Corporation Battle Creek Facility

Eaton Corporation's Battle Creek facility was a major source of PCB to Morrow Lake. This conclusion is based upon:

1. The correspondence among the type of PCB found in the storm sewer ditch for the former Eaton facility, the type of PCB found in current and former channels of the Kalamazoo River adjacent to and downstream of the outfall, the type of PCB found in sediments and fish of Morrow Lake, and the type of PCB found in sediment downstream of Morrow Lake and upstream of KRSG facilities.

2. The high level of PCB still remaining in the Eaton storm sewer ditch;

3. The elevated levels of PCB that can be found in the current and former channel of the Kalamazoo River downstream of Eaton's outfall in Battle Creek;

4. My study of potentially responsible parties (PRPs) upstream and downstream of Eaton's Battle Creek facility; and

5. Fish and sediment data throughout the Kalamazoo River.

The type of PCB discharged from the former Eaton facility was evaluated in a series of soil and sediment samples collected by Mr. Michael McLaughlin of SCS Engineers along the path of the current storm sewer ditch that historically was used to discharge waste from the facility to the Kalamazoo River and the current and former channel of the river downstream from the ditch. In five samples taken in the storm sewer ditch, PCB were quantified at concentrations ranging from 7.2 to 76 mg/kg. In all cases, PCB were quantified by the reporting laboratories as primarily Aroclor 1254. The chromatograms of the storm sewer ditch samples in most cases also reveal some peaks indicating the presence of Aroclor 1260, but at lower concentrations than Aroclor 1254. Mr. McLaughlin also collected 15 samples from the current river channel and what are believed to be former channels of the Kalamazoo River in Battle Creek located downstream of Eaton's outfall. PCB were detected in most of the samples at concentrations up to 6.9 mg/kg. As in the storm sewer ditch, PCB chromatograms for the former channel samples exhibit peaks corresponding primarily to Aroclor 1254 with evidence in most cases of peaks indicating the presence of lower concentrations of Aroclor 1260. Exhibit 1 shows chromatograms for Eaton ditch sample B-5 and former channel sample B-4A, along with a standard of Aroclor 1254. The peaks labeled D, E, and F mark the beginning of the pattern attributable to Aroclor 1254. The peak labeled X represents the end of the Aroclor 1254 pattern. Peaks Y and Z are not common to Aroclor 1254, but are clearly seen in Aroclor 1260 patterns, along with Peak X, which is common to both Aroclor 1254 and Aroclor 1260. The peaks labeled A, B, and C are very minor components of Aroclor 1254 and more likely indicate the variable presence of Aroclor 1248 in the former channel sediments. Aroclor 1248 is a type of PCB that is less chlorinated than either Aroclor 1254 or Aroclor 1260.

BBL evaluated the chromatograms of 138 sediment samples from Morrow Lake. These chromatograms were compared with chromatograms from Mr. McLaughlin's Battle Creek samples. In general, the PCB-containing sediment samples from Morrow Lake exhibit peak patterns corresponding primarily with Aroclor 1254, with consistent evidence corresponding to Aroclor 1260, and some evidence of small peaks corresponding with a less-chlorinated PCB that appears derived from Aroclor 1248. The absence of earlier eluting peaks found in Aroclor 1242, but not Aroclor 1248 point to the greater likelihood of the less-chlorinated PCB deriving from Aroclor 1248. Exhibit 2a shows the PCB chromatogram for sample ML3-3 (12- to 24-inch depth). This chromatogram illustrates the type of PCB commonly observed in Morrow Lake sediments. The peaks eluting between Peaks D and X correspond primarily to an Aroclor 1254 pattern, as in Exhibit 1. However, Peaks X, Y, Z and several smaller later eluting peaks exhibit a pattern corresponding to Aroclor 1260. As indicated for Exhibit 1, Peaks A, B, and C are attributed to the presence of Aroclor 1248. In comparison, the chromatograms from Morrow Lake are very similar to the chromatograms from Mr. McLaughlin's samples from Battle Creek, and indicate that Eaton Battle Creek was a source of PCB to Morrow Lake. Based upon my study of other PRPs

upstream and downstream of Battle Creek, of PCB in fish and sediment upstream and downstream of Battle Creek, and of the Morrow Lake and Mr. McLaughlin's data, I conclude that Eaton Battle Creek was the principal source of PCB to Morrow Lake. Evidence supporting this conclusion is provided below.

During 1999, BBL collected 27 fish samples from Morrow Lake and analyzed them for PCB. Included were 11 smallmouth bass fillet (skin off) samples, 11 carp fillet (skin on) samples, and 5 yearling smallmouth bass (whole body) samples. PCB were reported as Aroclor 1254 in all fish samples, with some portion quantified as Aroclor 1260 in 14 of the samples. PCB concentrations ranged from 41 µg/kg in a carp fillet (skin on) to 1,080 µg/kg, also in a carp sample. Exhibit 2b shows the PCB chromatogram of a smallmouth bass fillet (950 µg/kg PCB as Aroclor 1254 and 90 µg/kg PCB as Aroclor 1260). The peak patterns seen in this smallmouth bass fillet are representative of the patterns seen in most fish samples. The pattern between Peaks D and X is associated with Aroclor 1254. Peaks X, Y, and Z correspond to some lesser concentration of Aroclor 1260. This smallmouth bass PCB pattern shows strong correspondence with the patterns observed in Morrow Lake sediments, upstream former river channels, and the outfall of the former Eaton Battle Creek facility.

Despite discontinued operations of the former Eaton facility at Battle Creek, the storm sewer ditch soils and former and current channel sediments have retained evidence of PCB discharges at elevated concentrations that are above levels that have been determined by regulatory agencies to warrant response under CERCLA. Exhibit 3 plots PCB concentrations in recent samples from the Eaton storm sewer ditch, the former and current river channels, and historical sediment samples from Morrow Lake and along the Kalamazoo River to Lake Allegan Dam. The variability of PCB in the storm sewer ditch and former and current channel samples is generally consistent with variability found in sediment samples throughout the Kalamazoo River system. The existence of comparable levels of PCB and comparable PCB composition in the sampled former channels in Battle Creek and Morrow Lake identify the source of Morrow Lake PCB in the Battle Creek area. Although there are no available sediment data immediately upstream of Eaton's discharge, fish collected from upstream of the discharge location have much lower PCB levels than those found in Battle Creek. Taken together with the levels of PCB still present in areas impacted by Eaton's discharge, the correspondence between Morrow Lake and the former channel sediment both in terms of PCB composition and concentration lead to the conclusion that Eaton was the principal source of PCB to Morrow Lake.

In addition to evidence in Morrow Lake sediment of the PCB type found in the Eaton storm sewer ditch and current and former channels of the Kalamazoo River downstream of the outfall, Kalamazoo River sediments immediately downstream of the Morrow Lake Dam also exhibit evidence of Eaton PCB. Five sediment samples

from transects KPT3 and KPT4, which are downstream of Morrow Lake but upstream of any known KRSG discharge, contain measurable concentrations of PCB. In all five samples, the PCB was identified as Aroclor 1254. The chromatograms for these samples are similar to the chromatograms from Mr. McLaughlin's samples, and based upon my study of other PRPs, I am not aware of any facility other than Eaton to explain this PCB. Exhibit 4 shows the PCB chromatogram for sample KPT3-7 (0- to 2-inch depth). The pattern beginning with Peak D and ending with Peak X corresponds to Aroclor 1254. The Peak labeled "S" most likely corresponds to sulfur, rather than PCB. Peaks Y and Z, in combination with X and several later eluting small peaks, correspond to a pattern of Aroclor 1260. Peaks A, B, and C are likely evidence of some small, variable presence of Aroclor 1248. The PCB pattern shown for the Kalamazoo River sample in Exhibit 4 closely resembles the representative PCB pattern in Morrow Lake sediment and in Mr. McLaughlin's samples (Exhibits 1 and 2). This observation confirms the transport of Eaton's PCB to the downstream reaches of the Kalamazoo River.

Based upon sediment cores collected and analyzed by BBL as part of KRSG's CERCLA response, Morrow Lake sediment contains an estimated 4,200 pounds of PCB. The great majority of that PCB (approximately 90 percent) appears derived from Aroclor 1254. This also corresponds to the composition of PCB seen in Mr. McLaughlin's samples from Battle Creek. The remainder appears due to Aroclor 1260, although sediment chromatograms contain peaks that correspond to Aroclor 1248 at lower levels than Aroclor 1260.

In Morrow Lake, fish PCB concentrations are attributable to Eaton's PCB discharge. None of the PCB found in fish or sediment there is attributable to KRSG facilities as Morrow Lake is isolated upstream by the dam that forms the lake. Response costs incurred by the KRSG associated with RI/FS activities for Morrow Lake include fish, water, and sediment sampling and data analysis, including modeling and reporting. Approximately $735,000 in direct RI/FS response cost has been incurred in studying Morrow Lake. These costs include an estimate of $230,000 for development of a fate and transport model for the Kalamazoo River, and $505,000 in other RI/FS costs for Morrow Lake. This amount does not include certain general project management costs for which Eaton should bear some responsibility. In addition, KRSG has incurred substantial costs downstream of Morrow Lake, an area that also has been significantly impacted by releases from Eaton's Battle Creek facility. As presented in Exhibits 5 and 6, the total cost of the response downstream has been $25 million for the period through September 8, 2001.

The magnitude of the amount and the type of PCB remaining in Morrow Lake suggests that the quantity that passed over the dam has contributed significantly to the levels of PCB found in fish downstream. Morrow Lake retained a portion, but not all, of the PCB transported to it from the Eaton Battle Creek facility. The amount of

PCB that was transported below the Morrow Lake Dam can be estimated by approximating the retention efficiency of Morrow Lake. PCB would have been transported to Morrow Lake as well as past the Morrow Lake Dam attached to particles (particulate phase) and in a dissolved phase. As a result of particle deposition in Morrow Lake, the sediments contain an estimated 4,200 pounds of PCB. Measurements of suspended sediment levels upstream and downstream of Morrow Lake by KRSG as part of their response activities at the Site indicate a solids retention efficiency of approximately 40 percent. Assuming the same efficiency for retaining PCB, at least 6,300 pounds of PCB passed over the dam. I believe the actual amount is likely much higher because a portion of the PCB transported to the lake is not associated with particles and therefore would not have settled in the lake. If Connolly (1997) is correct and Morrow Lake retains only 22 percent of the entering particles, then the downstream transport particulate PCB would have been roughly 15,000 pounds.

In examining the significance of amounts of PCB remaining in sediments of the Kalamazoo River, the composition of PCB discharged by KRSG was approximated by using the amounts of PCB quantified as the various Aroclors in analyses of the solid paper making wastes known as residuals. The specific data used were from the waste characterization studies in the Remedial Investigations conducted by BBL for the operable units. The residuals in these operable units are largely comprised of the clays and fiber particles that settled in the KRSG members' clarifiers and lagoons, and are therefore representative of the KRSG members' discharges. Composition of PCB in the operable units as approximated by concentration weighted average are presented in Exhibit 7, where the average content of Aroclor 1254 and Aroclor 1260 quantified PCB is in the range of 0.2 to 4.7 percent. These data indicate that relatively little of KRSG members' discharge included PCB as Aroclor 1254 and Aroclor 1260. For purpose of comparison, Exhibit 7 also presents the amount of PCB quantified by various Aroclors for each of the downstream river sections, including both the submerged sediments and the exposed sediments of the former Plainwell, Otsego, and Trowbridge impoundments. As shown in Exhibit 7, the levels of these heavier PCB mixtures in the river and former impoundment exposed sediments are much higher, indicating the presence of PCB that cannot be attributed to KRSG.

Based upon my review of the Kalamazoo River Site data, the amount of Aroclor 1254- and 1260-derived PCB in Kalamazoo River sediments downstream of Morrow Lake is best approximated by the data for the exposed sediments of the Plainwell, Otsego, and Trowbridge impoundments. In the submerged sediment, including that of Lake Allegan, dechlorination has transformed some of the PCB to lower molecular weight PCB. The effect of this is the quantification of PCB as lighter Aroclors than the parent Aroclor released to the river. In contrast, the sediments exposed as a result of the drawdown of the dams in the late 1960s and early 1970s do not show the same extent of PCB dechlorination. In addition, these sediments contain roughly half of the estimated total

mass of PCB in the system. Therefore, based upon the amounts of PCB quantified as Aroclor 1254 and Aroclor 1260 in the exposed sediments of the former impoundments, it appears that Aroclor 1254 and Aroclor 1260 releases account for 19 to 25 percent of the PCB in river sediment downstream of Morrow Lake. Considering the magnitude of the total inventory of PCB in sediments and the amount that passed over the Morrow Lake Dam, a significant portion of those PCB should be allocated to Eaton Corporation.

Eaton Corporation, Kalamazoo Facility

Recent sampling of soils and sediments in the Zantman and Richardson drains that received wastewater and oil discharges from Eaton corroborate my earlier opinion that the Eaton Kalamazoo facility also discharged PCB to the Kalamazoo River, and that even a relatively large contribution might not be discernable in the Kalamazoo River. The samples are those collected by Mike McLaughlin of SCS Engineering. I have reviewed the analytical reports including chromatograms for these samples and determined that the presence of PCB in soils and sediments in these drainageways is consistent with their history of conveying wastewater and oils containing PCB from the Eaton facility to the Kalamazoo River.

Toxicity

The PCB mixture released by KRSG members is substantially less bioaccumulative and less toxic than the other mixtures released to the Kalamazoo River. The PCB mixtures in fish that cannot be attributed to KRSG members are comprised largely by the release of Aroclor 1254 and Aroclor 1260 to the system. Aroclor 1242, which was the predominant, if not exclusive, component of KRSG's discharges is much less bioaccumulative in fish and three to five times less toxic to humans and other mammals (e.g., wildlife) than Aroclor 1254, which comprises the majority of the non-KRSG PCB in the system that can be fingerprinted. Taken together with the data on PCB composition in fish, the toxicity information indicates that more than two-thirds of the Site risks are related to sources other than KRSG. I have previously reported in my July 1, 1999 report addendum that for equal amounts of Aroclor 1242 and 1254 in surface sediment, aquatic organisms would accumulate more than three times the amount of Aroclor 1254 PCB than Aroclor 1242 PCB.

In terms of both cancer and non-cancer risks, Aroclor 1242 is less toxic than Aroclor 1248, Aroclor 1254, and Aroclor 1260. This is illustrated using toxicity factors developed by the U.S. Environmental Protection Agency (USEPA) or reported by USEPA where available. USEPA toxicity information is used here because USEPA administers CERCLA, and their estimates of risk are central to determining the need for a response.

In USEPA's (1996) cancer dose-response assessment, upper-bound slope factors were estimated for the results of Brunner et al. (1996) experimental studies of Aroclors 1016, 1242, 1254, and 1260 in Sprague-Dawley rats. The central- and upper-bound potencies for the female rats, which were more sensitive than male rats, are presented in the table below.

Human Potency and Slope Estimates Derived from Liver Tumor Incidence in Exposed Female Sprague-Dawley Rats

	Central Slope (mg/kg-d)	Upper-Bound Slope (mg/kg-d)
Aroclor 1260	0.4	0.5
Aroclor 1254	1.2	1.5
Aroclor 1242	0.3	0.4
Aroclor 1016	0.04	0.07

These studies indicate that Aroclor 1254 is three times more potent than Aroclor 1242. Aroclor 1260's potency is 25-38 percent higher than Aroclor 1242.

The non-cancer toxicity factors available from USEPA, although comparatively limited, indicate Aroclor 1254 and Aroclor 1260 are more toxic than Aroclor 1242. USEPA's Integrated Risk Information System (IRIS), which provides toxicity information for use in environmental risk assessments, provides reference doses (RFDs) for Aroclor 1016 and Aroclor 1254. Aroclor 1016 is a mixture that is 40 percent chlorine by weight and is quite similar in composition to Aroclor 1242, which is 42 percent chlorine by weight, and much less similar to Aroclor 1254, which is 54 percent chlorine by weight. The RFD for Aroclor 1254 is 3.5 times the RFD for Aroclor 1016.

In providing guidance to risk assessors, USEPA (1996) has also suggested the analysis of dioxin Toxic Equivalency Quotients (TEQs) when PCB congener data are available to supplement cancer risk assessments. The suggested approach uses Toxic Equivalency Factors (TEFs) adopted by the World Health Organization (WHO), which relate the potency of PCB congeners to elicit effects mediated by binding to the aryl hydrocarbon (AH) receptor. Since binding to AH receptor is believed to mediate a variety of toxic effects, the use of WHO's TEFs, which are derived from very basic bio-chemical responses and not cancer bioassays, also provides a basis for comparison of potential toxicity with respect to non-cancer effects. The analysis of Aroclors by Kannan et al. (1987) and Frame et al. (1996) were used to represent levels of the non-ortho and the mono-/di-ortho congeners respectively in Exhibit 8. These applications of the WHO TEFs would indicate that Aroclor 1254 has 3.5 times the toxicity of Aroclor 1242 and that Aroclor 1260 is roughly twice as toxic as Aroclor 1242.

Using two sets of TEFs from Van den Berg et al. (1998), the toxicity of Aroclors to other mammals and birds can be compared in much the same way as done above for toxicity to humans. Exhibit 8 contains that comparison. On this basis, Aroclor 1254 is five times more toxic to mammals than Aroclor 1242. For birds, Aroclor 1242 is substantially more toxic (seven times) than Aroclor 1254. This is due to the different levels of congener 77 in Aroclors and its relatively high toxicity to avian species. However, it should be noted that ongoing Site-specific ecological risk assessment indicates that the actual levels of PCB exposure of avian species around the Site does not present a significant risk. Consequently, the difference in avian toxicity and the different abundances of congener 77 should not be given much, if any, weight in allocation at this Site.

The non-KRSG PCB contribution that can be chromatographically discriminated from the contribution from KRSG facilities is at least three times as toxic. The non-KRSG PCB contribution that can be chromatographically distinguished is principally comprised of Aroclor 1254 and, to a much lesser extent, Aroclor 1260. The human and mammalian toxicity factors for Aroclor 1254 are three to five times those for Aroclor 1242. Because Eaton's discharge was primarily Aroclors 1254 and 1260, and further because Eaton is the principal contributor of Aroclors 1254 and 1260 to Morrow Lake and a significant contributor of Aroclors 1254 and 1260 downstream of Morrow Lake, I conclude that Eaton's mass contribution of PCB to the Kalamazoo River is effectively magnified 3-5 times in terms of bioaccumulation and toxicity.

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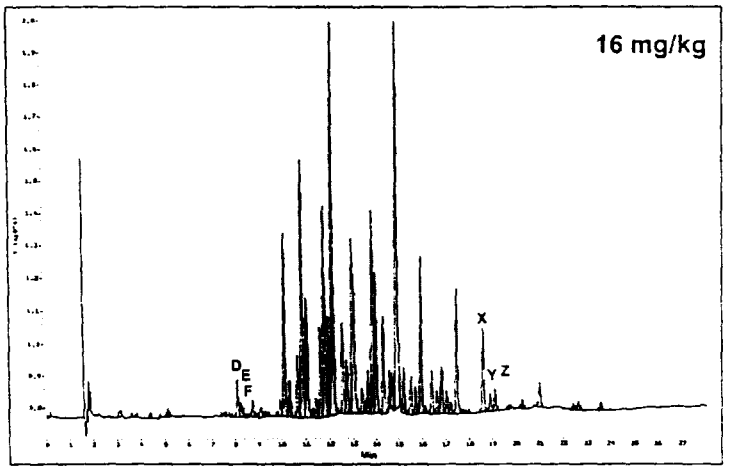
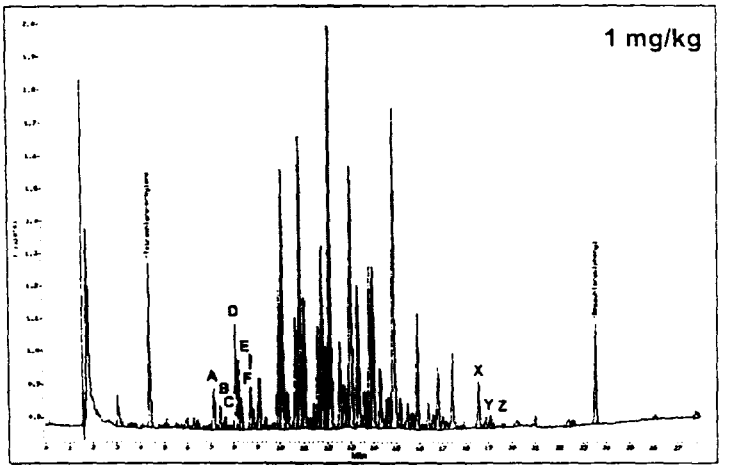
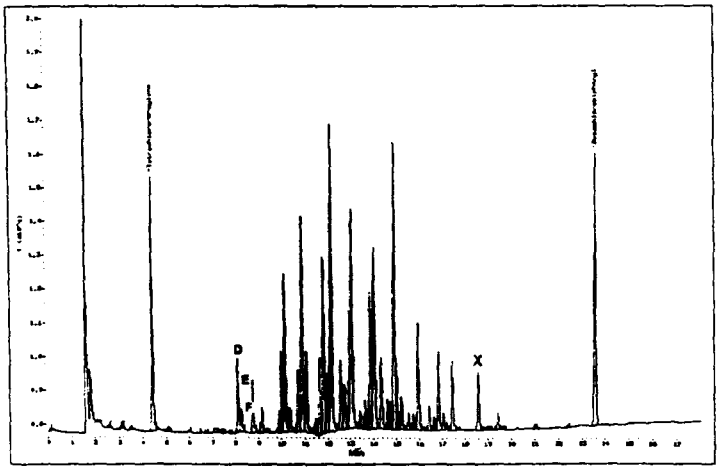
Exhibit 1
PCB Chromatograms for Eaton's Battle Creek Storm Sewer Ditch and Former River Channel Samples



a. Storm sewer ditch sample B-5



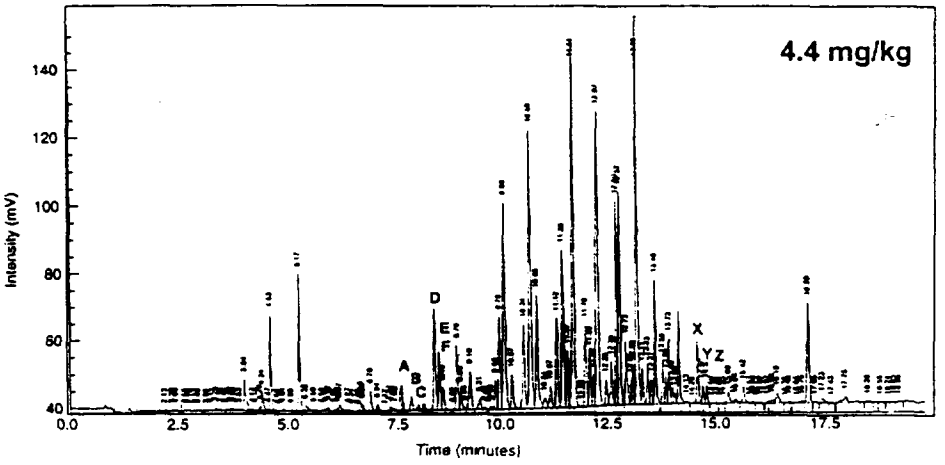
b. Former river channel sample B-4A



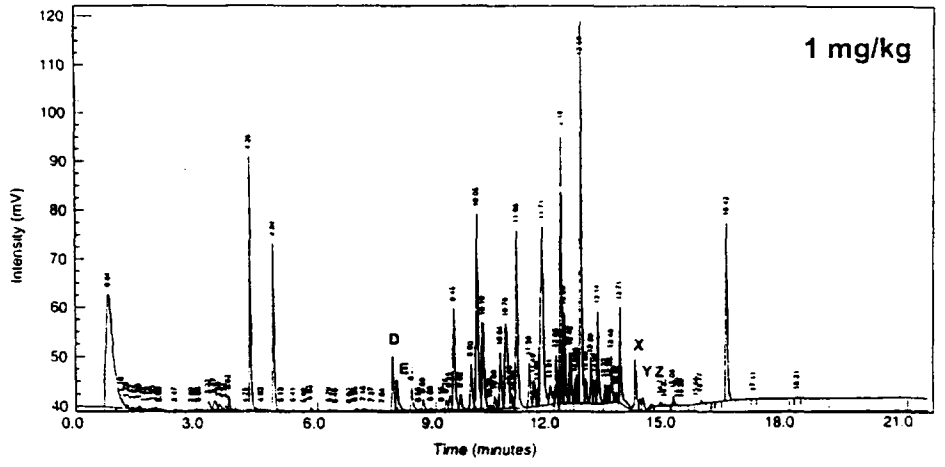
c. Aroclor 1254

10/01 SYR-D54-LBR
64502005/64502g03.cdr

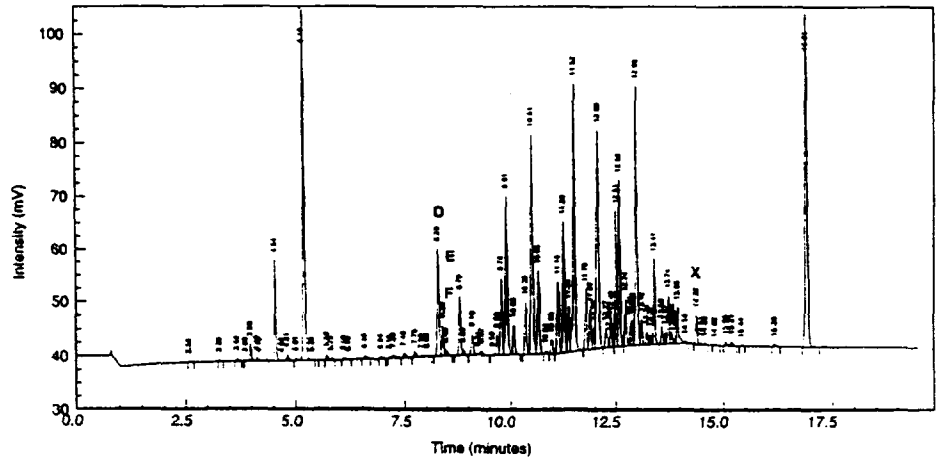
Exhibit 2
PCB Chromatograms for Morrow Lake Sediment and Fish



a. Sediment core ML3-3, 12-24-inch layer



b. Smallmouth bass fillet, without skin

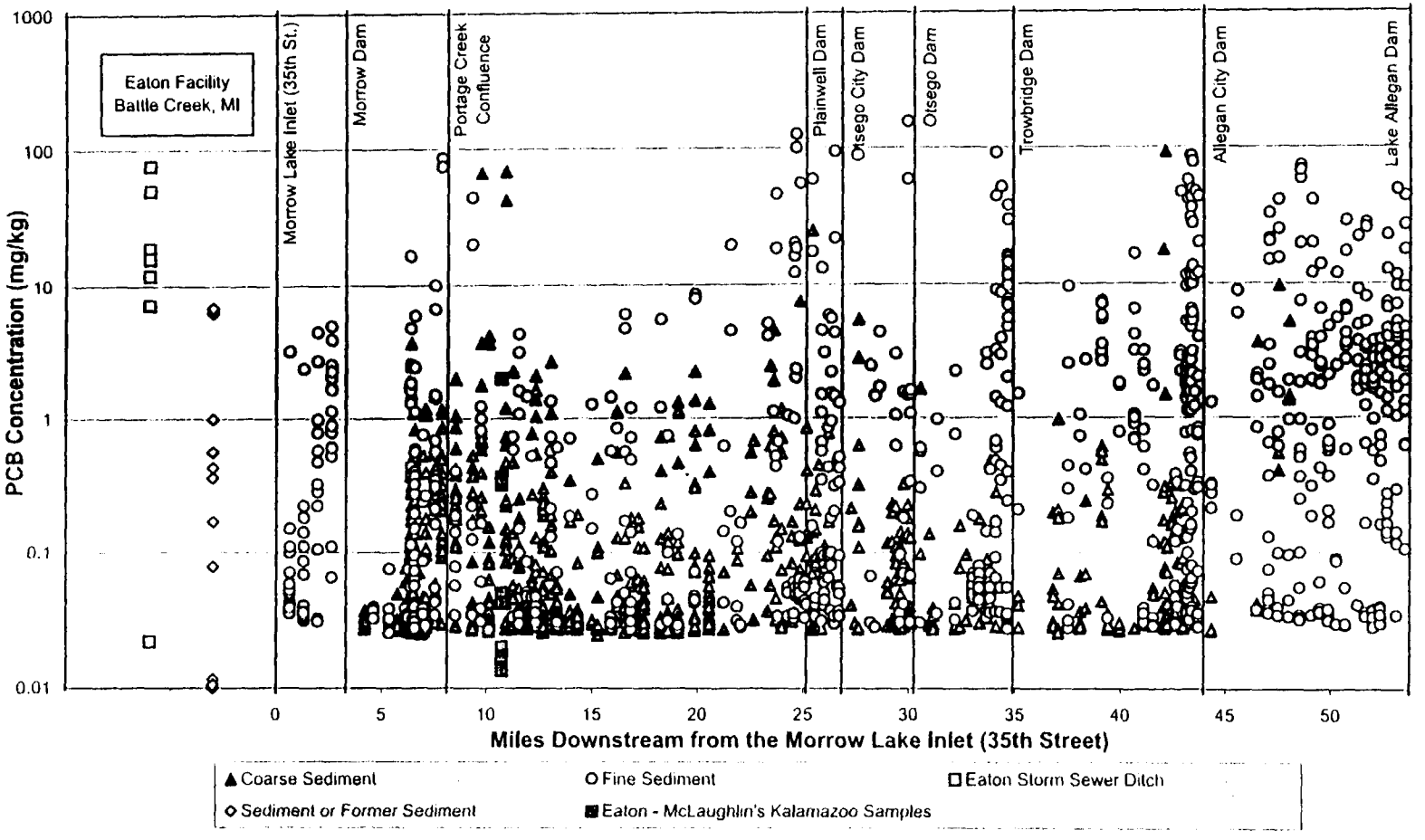


c. Aroclor 1254

10/01 SYR-054-LBR
64502005/64502g04.cdr

Exhibit 3

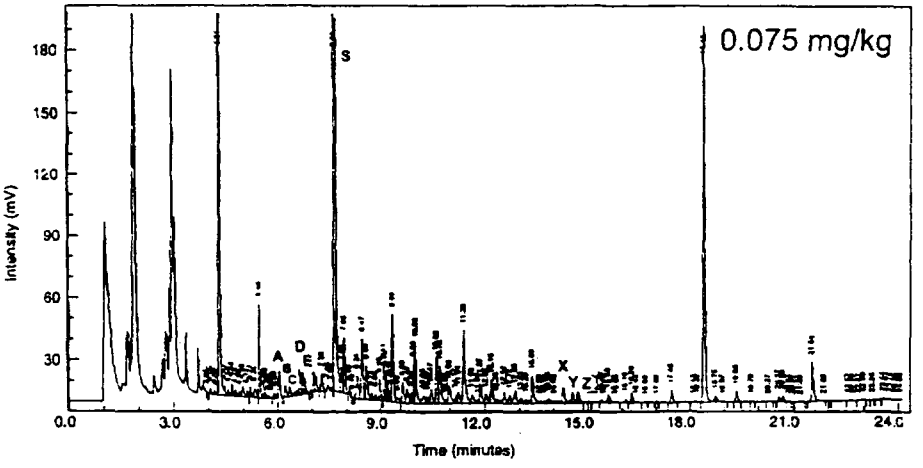
Comparison of McLaughlin's Eaton Battle Creek and Kalamazoo Samples to KRSG Sediment Samples



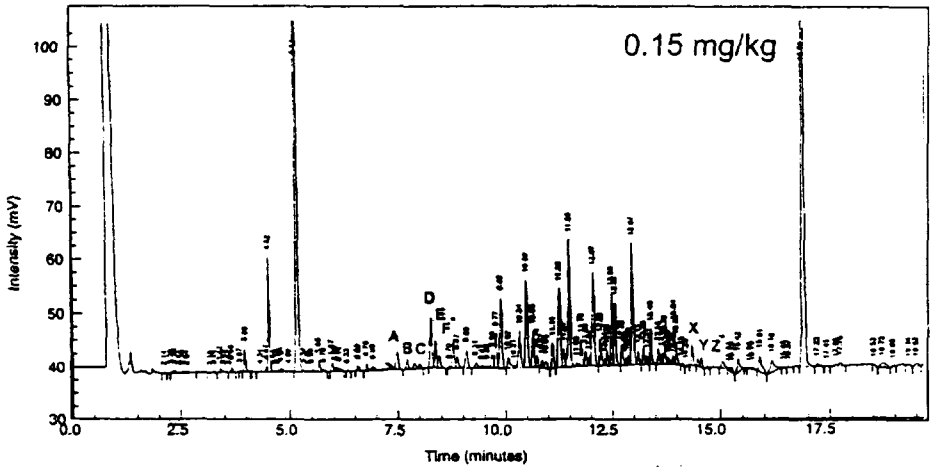
Notes:

1. Kalamazoo River sediment samples were from the "KPT-" locations, where cores were collected in 1993/1994 and analyzed in 1997 and 1999/2000. Samples were from depths not exceeding 24 inches.
2. Morrow Lake samples were from 16 sediment cores collected in summer 2000. Samples were from depths not exceeding 24 inches.
3. Eaton samples collected by SCS Engineers in 2001. Samples were from depths not exceeding 24 inches.

Exhibit 4
PCB Chromatograms for Sediment Samples from the Kalamazoo River Downstream of Morrow Dam and Morrow Lake



a. Sediment core KPT3-7, 0-2-inch layer



b. Sediment core ML1-3, 2-6-inch layer

Exhibit 5
Kalamazoo River Segment Costs
1990-1992

SEGMENT	DESCRIPTION	TOTALS
B	Portage Creek - Alcott St. to confluence	$ 27,893.46
C	River - Willow Blvd. Site to confluence	$ 295,740.74
D	River - Confluence to Plainwell Dam	$ 43,821.39
E	River - Plainwell Dam to Lake Michigan	$ 54,968.96
ALL SEGMENTS		$ 1,756,228.86
TOTALS		$ 2,178,653.41

Exhibit 6
Kalamazoo River Segment Costs
1993-2001 (Period 9)

SEGMENT	DESCRIPTION	TOTALS
2A/2B	Portage Creek - Alcott St. to confluence	$ 201,618.78
7A/7B	River - Georgia-Pacific to confluence	$ 177,407.52
9A/9B	River - Confluence to Ft. James	$ 199,172.00
11A/11B	River - Ft. James to N. American Aluminum	$ 108,154.49
13A/13B	River - N. American Aluminum to Plainwell Inc.	$ 350,492.19
15A/15B	River - Plainwell Inc. to Plainwell Impoundment	$ 136,794.44
15C/15D	River - Former Plainwell Impoundment	$ 390,480.64
16A/16B	River - Plainwell Dam to Otsego City Dam	$ 340,234.38
17A/17B	River - Otsego City Dam to Rock-Tenn	$ 70,578.50
19A/19B	River - Rock-Tenn to Otsego Impoundment	$ 18,193.65
19C/19D	River - Former Otsego Impoundment	$ 422,840.09
19E/19F	River - Former Trowbridge Impoundment	$ 682,826.81
20A/20B	River - Trowbridge Dam to Allegan City Dam	$ 500,334.63
21A/21B	River - Allegan City Dam to Lake Allegan Dam	$ 654,412.05
22A/22B	River - Lake Allegan Dam to Lake Michigan	$ 2,372,307.13
24	All Segments	$ 16,438,680.81
TOTALS		$ 23,064,528.11

Exhibit 7

PCB Composition of Residual Samples from Kalamazoo River Operable Units and Kalamazoo River Sediment Samples

Location	n	Percent of Total Detected PCB Mass Quantitated by Aroclor						
		% 1016	% 1242	% 1248	% 1254	% 1260	% 1016 +1242+1248	% 1254+1260
Operable Units								
12th Street Landfill	35	8.1	**45.6**	41.5	3.1	1.6	95.3	4.7
King Highway Landfill	105	0.0	**88.6**	11.2	0.1	0.1	99.8	0.2
A-Site	55	0.0	**89.2**	8.7	1.8	0.3	97.9	2.1
Willow Boulevard	32	1.2	**91.9**	5.9	0.4	0.5	99.1	0.9
Allied Paper, Inc.	111	11.3	**86.0**	2.4	0.3	0.1	99.6	0.4
River Segments								
Morrow Lake	51	0.0	**0.0**	1.8	89.6	8.6	1.8	98.2
Morrow Dam to Portage Creek	199	0.0	**36.5**	8.7	52.7	2.0	45.2	54.7
Portage Creek to Main Street, Plainwell	331	0.0	**58.3**	9.5	29.8	1.8	67.8	31.6
Main Street Plainwell to Plainwell Dam	58	0.0	**78.0**	11.9	10.3	0.0	89.9	10.3
Plainwell Dam to Otsego City Dam	63	0.0	**80.9**	1.9	17.0	0.2	82.8	17.2
Otsego City Dam to Otsego Dam	81	0.0	**58.8**	29.3	10.9	1.0	88.1	11.9
Otsego Dam to Trowbridge Dam	87	0.0	**69.0**	8.5	22.1	0.4	77.5	22.5
Trowbridge Dam to Allegan City Line	85	0.0	**44.1**	23.9	19.2	12.8	68.0	32.0
Allegan City Line to Allegan City Dam	140	0.0	**89.8**	2.4	7.8	0.1	92.2	7.9
Lake Allegan	228	0.0	**87.0**	3.8	9.2	0.1	90.8	9.3
Former Impoundment Exposed Sediment								
Plainwell	125	0.3	**2.8**	77.8	14.3	4.8	80.9	19.1
Otsego	122	18.3	**20.7**	35.7	23.6	1.7	74.7	25.3
Trowbridge	194	9.1	**3.2**	66.2	16.5	5.0	78.5	21.5

(See notes on page 2)

Exhibit 7

PCB Composition of Residual Samples from Kalamazoo River Operable Units and Kalamazoo River Sediment Samples

Notes:

Results of duplicate samples were averaged.

Values for each location are concentration weighted averages developed by summing all of the reported concentrations for each Aroclor, dividing by the sum of total PCB concentrations for all samples at that location. The resulting proportions of Aroclors are expressed as percentages.

Data include samples from the Operable Units (OUs) designated as "residual" in the Kalamazoo River database.

12th Street Landfill samples were from locations DB-11, DB-13, DB-3, DB-5, DB-7, DB-9, MW-1, MW-2B, MW-3, MW-4B, MW-5, SB-1, SB-2, SB-4, SB-5, SB-6, and SB-7.

King Highway Landfill samples were from locations B1-1, B1-2, B1-3, B2-1, B2-2, B2-3, B3-1, B3-2, B3-3, KHL-SB-2, KHL-SB-5, KHL-SB-8, KHL-SB-10, KHL-SB-11, KHL-SB-12, KHL-SB-13, KHL-SB-14, MW-9A, MW-9B, MW-10A, MW-10B, C4-1, C4-4, C4-5, C4-95-13, C4-95-18, C4-95-2, C4-95-20, C4-95-25, C4-95-27, C4-95-30, C4-95-32, C4-95-35, C4-95-36, C4-95-37, C4-95-39, C4-95-5, and C4-95-9.

A-Site samples were from locations AMW-6B, AMW-7B, AMW-8B, AMW-9B, AMW-10B, AS-1, AS-2, AS-3, DWA-FLA-S, FLA-SB-7, FLA-SB-12, FLA-SB-18, FLA-SB-24, SB-3A-101, SB-3A-102, and SB-3A-104.

Willow Boulevard samples were from locations DWA-SB-14, DWA-SB-26, DWA-SB-36, DWA-SB-51, WB-1, WB-2, WB-3, WB-4, WB-5, WMW-3A, WMW-4A, and WMW-4B.

Allied OU samples were from locations BHDL-123, BHDL-22, BMP-1, BMP-2, BMP-3, DLHB-1, DLHB-2, DLHB-3, DLHB-6, FLF-1, FLF-2, FLF-3, MLSS-1, MLSS-2, MLSS-3, MLSS-4, MLSS-5, MW-120B, MW-121B, MW-125B, MW-126A, MW-126B, MW-8A, WA-1, WA-2, WA-3, WA-4, WA-5, WA-6, WA-7, and WA-8.

Morrow Lake samples were from 16 sediment cores collected in summer 2000.

Kalamazoo River sediment samples were from the "KPT-" locations, from which cores were collected in 1993/1994 and analyzed in 1997 and 1999/2000.

Former Impoundment samples were collected as part of the Former Impoundment Exposed Sediment Investigation, presented in Technical Memorandum 12.

Exhibit 8
TEQs Estimated for Aroclors

IUPAC # Sample ID	Wt % AR 1242	Avian TEQ AR 1242	Mammal TEQ AR 1242	Human TEQ AR 1242	Wt % AR 1248	Avian TEQ AR 1248	Mammal TEQ AR 1248	Human TEQ AR 1248	Wt % AR 1254	Avian TEQ AR 1254	Mammal TEQ AR 1254	Human TEQ AR 1254	Wt % AR 1260	Avian TEQ AR 1260	Mammal TEQ AR 1260	Human TEQ AR 1260
77	0 520	26 000	0.052	0.260	0 610	30.500	0.061	0.305	0.060	3.000	0.006	0.030	0 026	1.300	0.003	0.013
81	0 000	0.000	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
105	0 750	0.075	0 075	0.075	1.820	0.182	0.182	0.182	1.510	0 151	0 151	0.151	0 250	0.025	0 025	0.025
114	0.000	0 000	0.000	0.000	0.250	0.025	0.125	0.125	0 300	0.030	0 150	0.150	0.000	0.000	0.000	0 000
118	0 800	0 008	0.080	0.080	2.350	0.024	0.235	0.235	8.780	0.088	0 878	0.878	0.950	0.010	0 095	0 095
123	0 000	0 000	0.000	0 000	0.000	0 000	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0 000	0.000
126	0 002	0 200	0 200	0 200	0.0062	0.620	0.620	0.620	0.0046	0 460	0 460	0 460	0 00083	0 083	0.083	0.083
156	0 000	0 000	0 000	0 000	0.000	0.000	0.000	0.000	0.920	0 092	0 460	0 460	0 680	0 068	0 340	0.340
157	0 000	0.000	0 000	0.000	0 000	0.000	0.000	0.000	0.000	0 000	0 000	0.000	0 050	0 005	0 025	0 025
167	0 000	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.650	0 007	0 007	0.007	0.250	0.003	0 003	0.003
169	0.000	0 000	0.000	0 000	0.000	0 000	0.000	0.000	0 000066	0.000	0 001	0.001	0.000	0 000	0 000	0.000
170	0 000			0.000	0 250			0.025	0.650			0 065	3 760			0 376
180	0 000			0.000	0.250			0.003	0.740			0 007	11 100			0.111
189	0 000	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0 250	0 003	0.025	0.025
Sum	2 07	26 28	0 41	0.62	5.54	31.35	1.22	1.49	13 61	3 83	2.11	2 21	17 32	1.50	0 60	1 10

Notes:
1. TEQs based on cited TEFs x 1000
2. Composition of Aroclors from Kannan et al. (1987) for non-ortho congeners 77, 126, 169 and Frame et al. (1996) for the other congeners.
3. Avian and mammal TEFs from Van den Berg et al. (1998) and human TEFs from World Health Organization as reported by Ahlborg et al. (1994) and USEPA (1996)